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The High School to First-Year College Instructional Transition: An Investigation of the Predictions and Perceptions of STEM Students

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THE HIGH SCHOOL TO FIRST-YEAR COLLEGE INSTRUCTIONAL TRANSITION:

AN INVESTIGATION OF THE PREDICTIONS AND

PERCEPTIONS OF STEM STUDENTS

By

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By Emma S. Toth

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An Abstract of the Thesis Presented
in Partial Fulfillment of the Requirements for the
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Recent national reports have cited ongoing issues in undergraduate science, technology, engineering, and mathematics (STEM) education. Fewer than half of first-year undergraduate students who start in STEM fields graduate with a STEM degree six years later. Most of this attrition occurs between the first and second year of college, and students often cite instructional practices used in introductory college courses as a prominent reason for leaving. Furthermore, students from backgrounds that are underrepresented in STEM fields, including first-generation college students, leave STEM majors at higher rates than their classmates. Recent data show that the instructional practices used in introductory college STEM courses differ significantly from those used in high school science classes, suggesting that incoming college students may hold expectations that are not well aligned with actual instructional practices.

To more fully understand this prediction, data were collected from online surveys given to students enrolled in large introductory STEM courses at three institutions. Throughout this project, first-week and mid-semester surveys were developed, piloted, and modified. Survey questions asked students about their expectations and perceptions regarding the teaching practices used in undergraduate courses, how class time would be spent, any differences they expected to see between

their high school and university STEM courses, as well as concerns they had about this instructional transition.

This project focuses on the analysis of student predictions about the percent of class time that will be dedicated to lecture in introductory STEM courses. Specifically, differences in predictions between first-generation and continuing-generation college students, and between students taking classes on a college campus for the first time and students returning to campus were investigated. Results showed that all students underpredict the percent of class time that will be dedicated to lecture in introductory STEM courses. First-generation and first-semester college students predict even less lecture than their peers. Misalignment between student predictions and actual instructional practices could impact student experiences during the transition from high school to the first-year of college. Implications for practices and approaches to future work are discussed.

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CHAPTER 1

INTRODUCTION

STEM Attrition

There is a growing need for science, technology, engineering, and mathematics (STEM) graduates in the United States job market (President's Council of Advisors on Science and Technology, 2012). In the state of Maine alone, the need for engineers is expected to continue increasing over the next five years (Urbina & Friess, 2017). However, retention of students in STEM majors remains a problem at universities and colleges across the United States. Even though more students are showing initial interest in pursuing majors in STEM fields, the number of students graduating with these types of degrees is not increasing (Eagan, Hurtado, Figueroa, & Hughes, 2014). In fact, less than half of those students who start out with a STEM major will have graduated with a STEM degree six years later (Eagan et al., 2014; Seymour & Hewitt, 1997). Most of this attrition occurs between the first and second year of college (Seymour & Hewitt, 1997). Additionally, students from backgrounds that are underrepresented in STEM fields, such as first-generation college students, are leaving STEM majors at a higher rate than their classmates (Cataldi, Bennett, Chen, & Simone, 2018; Chen, 2013). This unequal attrition leads to a systematic underrepresentation of certain populations within STEM majors that is particularly problematic given the critical need for a strong STEM workforce (President's Council of Advisors on Science and Technology, 2012). Ideally, careers in STEM fields should be open to all individuals and the demographics of STEM fields should increasingly align with those of the general population. Efforts to address this ongoing underrepresentation are clearly needed.

Instructional Practices

When asked about their reasons for leaving STEM majors, students often cite the poor teaching practices engaged by faculty (Seymour & Hewitt, 1997). Students from seven different institutions were interviewed over the course of three years in a study focused on learning more about students' reasons for leaving SME (Science, Mathematics, and Engineering) majors in college. These students were asked about the decision to enter, persist in, or leave SME majors, and report on their experiences in classes of those subjects. The researchers found that the three most commonly discussed concerns were cited by both "switchers" (students who had left SME majors) and "non-switchers" (students who persisted in an SME major). These concerns included (1) lack or loss of interest in SME disciplines, (2) non-SME majors offering better education or more interest, and (3) poor teaching by SME faculty. "Poor teaching by SME faculty" showed up in 90% of all students' concerns. In particular, traditional lecturing from a textbook, lack of explanations, and minimal interactions between students and the instructor were all commonly brought up as reasons for leaving SME majors. Even students who persisted in SME majors cited these types of instructional practices as problematic. Based on the prevalence of these concerns, the types of instructional practices used in STEM classrooms, particularly in introductory classrooms, require further investigation.

Recent studies have shown that the types of instructional practices to which students are exposed in their introductory college courses are different from what they experience in the pre-college classroom. One study characterized and compared how class time was spent in over 480 classrooms from the middle school, high school, first-year college, and advanced college levels (Akiha et al., 2018). The Classroom Observation Protocol for Undergraduate STEM (COPUS) (M.K. Smith, Jones, Gilbert, & Wieman, 2013) was used to characterize how class time was being spent by both students and instructors across all four of these educational levels. The results showed that the largest instructional shift occurs between high school and first-year college courses. For example, the median percent of class time spent lecturing shifted from 32% in high school to 80% in first-year college, which is an increase more than 10-fold the difference between any other two adjacent educational levels. Researchers also found that this shift cannot be accounted for solely on the basis of differences in college class size, class length, or whether or not a particular course had an associated laboratory session. For example, smaller classes do not necessarily exhibit a lower percentage of time spent lecturing. Additionally, when high school teachers and college instructors were asked to predict how class time was spent across these levels, many predicted that students would experience a gradual increase in class time spent lecturing as they moved through their educational career. A second prediction was that the first-year college courses would have significantly more class time spent lecturing than any other level. However, the actual trend showed that the only major increase in the percent of class time spent lecturing was between high school and first-year college courses. Based on these results, more communication is necessary between instructors at each of these levels. As most instructors are unfamiliar with instructional practices that occur at levels besides their own, it is difficult to prepare students for a transition in instructional practices, or to understand how to help them navigate these changes successfully.

To characterize the types of instructional practices students are experiencing, several studies have focused specifically on university-level STEM courses. For example, COPUS observation data from over 2,000 STEM college classrooms at 25 institutions in North America showed that in over half the observed class meetings, “didactic” instructional practices were used (Stains et al., 2018). Instruction is described as “didactic” when more than 80% of class time is spent lecturing. Another study, which explored STEM teaching at a single institution, showed that instructors do not always fall into just one of two extremes (M.K. Smith, Vinson, Smith, Lewin, & Stetzer, 2014). Instead of “instructors who lecture” and “instructors who use active learning techniques,” classroom observations of about 50 STEM courses showed that a continuum of instructional practices was present across courses. While all observed instructors presented material using lecture at some point during their class, the percent of time spent “presenting” ranged from 2% to 95% of class time, with plenty of instructors falling in between the two extremes. Additionally, the researchers found that the size of the class was not necessarily predictive of the type of instructional practices being used. Similar results were found in a study that included observations and characterizations of the teaching practices of 73 instructors from 28 different research institutions in the United States (Lund et al., 2015). The researchers worked to profile instructors' classrooms into broad categories such as "Lecturing," "Socratic," "Peer Instruction," or "Collaborative Learning." These categories were broken down even more specifically into subcategories; for example, "Student Centered Peer Instruction" and "Transitional Lecture." They also found that large enrollment courses and fixed seat classrooms were not barriers to the types of instructional practices employed.

It is important to recognize that the high school to first-year college instructional transition is a noteworthy shift for students. The shift from high school to first-year college is the most dramatic instructional transition they experience between starting middle school and finishing college (Akiha et al., 2018). However, the types of instructional practices used at the university level are not uniform, even at the introductory course level (Lund et al., 2015; M.K. Smith et al., 2014). Therefore, students may be adjusting to a wide variety of unfamiliar teaching practices, even during their first-semester of college. Furthermore, instructors often do not have an accurate view of the types of instructional practices that are common at levels besides their own (Akiha et al., 2018). Therefore, it is not surprising that students' decisions about staying in STEM majors are influenced by instructional practices at the undergraduate level. Not only is lecture prevalent (Stains et al., 2018), but this is likely a dramatic shift from how students are used to class time being spent in pre-college classrooms (Akiha et al., 2018). Most STEM attrition occurs between the first and second year of college (Seymour & Hewitt, 1997), meaning that many students leave STEM majors after experiencing this transition and unsatisfactory teaching practices.

Factors Influencing the First-Year Student Experience

Despite the prevalence of lecturing in university level STEM classrooms, recent studies have shown that active learning techniques are far more beneficial for student learning and retention. To answer the question of whether active learning increased student performance and decreased failure rates in STEM courses, researchers conducted a meta-analysis of previously published literature (Freeman et al., 2014). The results showed that students enrolled in active learning sections of courses had an average increase of 6% on examinations scores compared to students enrolled in traditional lecture-based sections. Students in the lecture-based section were also 1.5 times more likely to pass. This study showed not only how classroom instructional practices may decrease student failure rate, but also how active learning benefits students and their academic performance. Therefore, the types of instructional practices used in introductory courses are a critical component of a student's experience in introductory college STEM courses. During the high school to first year college instructional transition, students are experiencing a large increase in the percent of class time that is dedicated to lecture, and therefore instructional shift, (Akiha et al., 2018), but this shift is moving farther away from active, evidence-based teaching practices that can help students to be successful.

In addition to the types of instructional practices used, there are other factors that can influence the high school to first-year college transition for students. For example, the expectations that incoming first-year students hold about first-year courses can impact their experiences, particularly if those expectations are inaccurate. One study found that students' expectations about the difficulty of their upcoming college courses and their expectations about their ability to handle that difficulty impacted performance (J. S. Smith & Wertlieb, 2005). Three surveys, which asked questions about how students expected college to differ from high school both socially and academically, were administered to students throughout the year. The first survey, measuring student expectations, was administered during the second week of the fall semester. The second survey, measuring first-semester experiences, was administered near the end of the fall semester. Finally, students completed the third survey at the end of the spring semester, reporting on cumulative first-year experiences. These researchers found that, in general, student expectations were not well aligned with actual first-year academic and social experiences. For example, students reported being lonelier on the final survey than they had expected to feel at the beginning of the fall semester, and students reported needing to make fewer changes to their study habits from high school than they predicted would be necessary for success. Surprisingly, the results showed that students with lower academic and social expectations were more successful academically than students with higher expectations.

In order to better understand what expectations incoming students hold, one study investigated how students enrolled in an introductory biology course expected class time to be spent, and how well those expectations aligned with the actual structure of the course (Brown, Brazeal, & Couch, 2017). Researchers distributed a survey to almost 400 students, asking them to report expectations about how class time would be spent in their introductory biology course. The researchers used Expectancy Value Theory, which was originally used in studies of psychology about personal space, as a lens through which to view their results (Burgoon, 1978). Expectancy Violation Theory suggests that if an interaction or experience is different from what was expected, it can have a negative impact on that experience. Focusing on the alignment between the expectations of introductory biology students and actual course structure, the authors argued that if student expectations and class practices are not well aligned, students will benefit less from the course (Brown et al., 2017). The results showed that compared to upperclassmen, first-year students expected more class time to be spent on active learning activities (as opposed to lecture). Additionally, first-year students overestimated the amount of class time that would be spent on active learning activities in their introductory courses. Therefore, instructors could spend more time on active learning without violating the expectations of the incoming students.

Student expectations of how class time will be used, and their accuracy, can impact experiences in STEM courses; student perception, buy-in, and engagement are other contributing factors. In one study, students in a social and behavior science course were asked to report on their perceptions of three different categories of activities used throughout the class (Machemer & Crawford, 2007). These categories included traditional (lecture), independent active learning, and cooperative learning. Cooperative learning was defined as any kind of group work in the class where an individual is responsible for both their own learning, and the learning of the group (*e.g.,* talking with a group about discussion question, working with a group to complete an activity or assignment). The results showed that students value any activity that they see as helping them to achieve a better exam score. Additionally, they found that while students valued both lecture and independent active learning, they reported valuing cooperative learning much less, as they did not like being held responsible for the learning of their classmates.

Students' perceptions of a course, its activities, and instructor can have a significant impact on their performance and experiences in that course. For example, student perceptions of in-class activities can impact their level of "buy-in" (Brazeal & Couch, 2017; Cavanagh et al., 2016). Buy-in is described as a student's level of participation, and belief that an activity will support learning and have a positive outcome. In one study, students enrolled in a human anatomy course answered a survey that included questions about their exposure to various classroom activities, followed by questions about their level of involvement and engagement in each (Cavanagh et al., 2016). For example, students were given an activity and asked to choose "I did this," "I did not do this," or "I did this but did not understand it." If they reported participating in and understanding the activity, follow up questions probing level of buy-in and engagement were administered. The results showed that increased student buy-in was related to increased student engagement in course material, which in turn was associated with better course performance. A study at the University of Nebraska showed similar results (Brazeal & Couch, 2017).

Over 1000 students in an introductory biology course completed a mid-semester survey about student buy-in and resistance to the in- and out-of-class use of formative assessments, with questions asking students about their perceptions of these activities. The results showed that student buy-in was predictive of exam scores and course grades. Those students who reported higher buy-in for these increases in course structure showed increased performance in the courses. The researchers also found that student buy-in and perceptions differed between course sections, showing that the techniques individual instructors use to implement these formative assessments can impact and shape student perceptions. Additionally, research at the University of Connecticut showed that a student's trust in their instructor contributed more to performance than their perception of their own intellectual ability (Cavanagh et al., 2018).

There are many factors impacting the experience of incoming students during their first-year college STEM courses. First, the types of instructional practices utilized can either help or hinder a student's success in the classroom. Studies have shown that using evidence-based teaching strategies, such as active-learning, can increase student learning outcomes in courses (Freeman, 2014). However, the expectations that a student holds coming into these first-year courses also has an impact. The unrealistic expectations students hold about first year college courses can negatively influence their performance in those courses (J. S. Smith & Wertlieb, 2005). Additionally, increased levels of student buy-in and positive student perceptions of the activities used in these courses can benefit student learning (Brazeal, Brown, & Couch, 2016; Brown et al., 2017; Cavanagh et al., 2016; Huxham, 2005; Machemer & Crawford, 2007).

First-Generation College Students

Although factors such as variation in instructional practices, student expectations, and motivation can impact the experiences of all incoming college STEM students, these experiences vary for students from different demographic backgrounds. First-generation college students are defined as students who do not have at least one parent who has completed a bachelor’s degree (https://firstgen.naspa.org/blog/defining-first-generation). First-generation college students are leaving STEM majors at higher rates than their continuing-generation classmates (Cataldi et al., 2018; Chen & Carroll, 2005). Studies have shown that first-generation college students are less prepared to interact with faculty upon entering college (Padgett, Johnson, & Pascarella, 2012), and have lower degree aspirations than their peers (Terenzini, Springer, Yaeger, Pascarella, & Nora, 1996). First-generation students spend more hours working at jobs unrelated to college, and fewer hours studying during the school week, make fewer academic gains in the first-year of college, and generally have a more difficult transition from high school to college than their continuing-generation counterparts (Pascarella, Pierson, Wolniak, & Terenzini, 2004).

Many studies show in-depth evidence of the unique experience and struggles that first-generation students encounter during the high school to first-year college instructional transition. For example, it has been well established and widely accepted that active learning is more effective than solely lecturing in college classrooms (Freeman et al., 2014; Haak, HilleRisLambers, Pitre, & Freeman, 2011; M.K. Smith, Wood, Krauter, & Knight, 2011). It is argued that it is now important to ask questions about how active learning techniques work, and for which groups of students (Eddy & Hogan, 2014). For example, previous studies had shown that first-generation students performed better in a classroom that they perceived as interdependent, and often came from backgrounds that emphasized practical learning over abstract information (Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012). After implementing a course structure intervention in an introductory biology course at a large research institution, researchers collected data on student performance and perceptions (Eddy & Hogan, 2014). Increasing course structure included having students complete regular homework assignments, participate in class activities, and complete guided-reading questions. Low-structure versions of the courses included traditional lecture-style course meetings and very few homework assignments. The results showed that increasing course structure led to an increase in performance for all students, but a disproportionately high increase for black and first-generation students. Additionally, failure rate decreased for all students, but without any significant differences between race, gender, etc.

The academic approaches that first-generation college students use in college differ from their continuing-generation student counterparts. In a study conducted at a four-year, public institution, a researcher interviewed a variety of students throughout their freshman and sophomore years at university (Yee, 2016). Yee used parental education as a way to define and investigate social class among the students. She found that first-generation (students whose parents had never attended college) and middle-class students (students whose parents held four-year degrees) had very similar expectations about the academic differences between high school and college classrooms. However, the approaches to dealing with these differences varied considerably. Both groups of students expected their college classes to be more difficult than their high school classes, and believed that their professors would not go out of their way to help them. However, middle-class students responded to this challenge with the expectation of having to initiate conversations with instructors, reach out via email, or visit professors, teaching assistants, or tutors on a regular basis. Yee describes the middle-class students as feeling entitled to individualized help, which most of them were ready and willing to arrange for themselves. Middle-class students were more likely to feel willing and comfortable enough to reach out to professors for help, information, or even for a casual conversation. While first-generation students had the same idea that college professors would be less accessible than their high school teachers, they believed that the way to succeed in college would be to become more independent in studying. When struggling, first-generation students were more likely to reread textbooks or spend more time studying than to ask for help. Many expressed or showed that they were unsure of the best way to ask for or get the help that they needed. Yee found that first-generations students would generally only reach out to a professor in dire situations, often when it was too late to receive any substantive help.

Furthermore, results showed that even though first-generation students were less likely to develop one-on-one relationships with their professors, they knew why it would be important and helpful (letters of recommendation, *etc*.) to do so. In addition to the variation in success that these differences in approaches led to, Yee also reported on how the strategies of middle-class students were generally more well accepted by faculty. The interactive “rules of engagement” that middle class students follow are more closely aligned with what faculty members perceive as “engaged” students. The author argued that the scope of “engagement” should be expanded to include those students who are still working hard, but independently. Despite the alternative methods for success attempted by first-generation students, they deserve the same opportunities, information, and approval as their middle-class peers.

Other studies have focused more on the motivational and psychological aspects that have an impact on the performance and experiences of first-generation students. For example, one group of researchers described how a culture match between students and their surroundings, including social norms and representations, can be an important factor impacting student performance (Stephens, Fryberg, et al., 2012). Most American universities have an “Independent Model of Self” and encourage students to work towards success with little reliance on others. However, this does not match the cultural background of a number of first-generation students, many of whom come from working-class families, where they are taught values of interdependence and acting on the needs of others.

First-generation college students have unique experiences in their first-year college STEM courses compared to their continuing-generation peers. A common thread emerging from research on first-generation college students is that differences in commitments, expectations, and backgrounds contribute to their experiences (Pascarella et al., 2004; Stephens, Fryberg, et al., 2012; Yee, 2016). It is important to recognize that the struggles that first-generation students experience may not be due to differences in ability or intelligence, or even academic preparedness, but may stem from the fact that they are dealing with the challenges of first-year college in a unique way. One compelling question is that if instructors are more aware of how different groups of their students are dealing with these challenges, will they be better able to help all of the students in their classroom to make this transition and be successful in college academics?

Research Questions

There are many factors that may be contributing to the high attrition rates of students in STEM majors. With the growing need for STEM graduates, an increased understanding of these trends is essential. Additionally, research about how instructional practices may influence the high school to first-year college transition is an area where not much previous research has been conducted. Most STEM attrition is occurring between students' first and second year of college, and in many cases is attributed to the types of instructional practices being used in introductory STEM courses. However, there are steps instructors can take to help address these issues. In this project, data were collected from students enrolled in introductory STEM college courses about the high school to first-year college instructional transition. Using an online survey tool, student data were collected at two time points during the fall semester; student prediction data were collected during the first week, and student perception data were collected mid-semester. Observation data from the classes in which these students were enrolled were also collected. By collecting these data, we were able to investigate the expectations and experiences of incoming STEM college students. Specifically, we asked: (1) What types of instructional practices do students predict when entering college? (2) Do those predictions vary by student demographics? and (3) Do differences in predictions between students from various demographic backgrounds persist through to middle of the semester perceptions? The answers to these questions lead to a more complete understanding of how students, especially first-generation college students and students taking classes on a college campus for the first time, transition from high school to college STEM academics. Throughout the following chapters, the research questions described above are addressed in detail. Chapter 2 focuses on the development of the student survey as well as the pilot study and preliminary data analysis. Chapter 3 describes a more extensive round of data collection using updated versions of the survey and techniques that were refined during the pilot study. Finally, a discussion of these results and their implications for this research and future directions can be found in Chapter 4.

CHAPTER 2

PILOT SURVEY AND QUESTION DEVELOPMENT

Overview

To begin addressing the research questions, data were collected from a pilot survey distributed online to students who were enrolled in introductory college STEM courses at two institutions. This chapter focuses on the development of student surveys, and how preliminary data from those surveys and feedback from faculty and students were used to refine the survey questions. Methods, including cleaning and organization techniques, are described. Additionally, a discussion of the observation protocol used to characterize how class time was being used in introductory STEM courses is included. These observations were used to draw comparisons between student predictions, perceptions, and actual instructional practices. Except where noted in Chapter 3, the methods outlined in this chapter were used for later more extensive data collection and analysis.

Survey Development and Distribution

During Summer 2017, a pilot survey was developed which addressed the project research questions (Appendix A). This survey included a variety of qualitative and quantitative questions. Quantitative questions asked about student predictions concerning how class time will be spent in their college STEM courses. For example, we asked students to predict what percent of class time will be dedicated to lecture on an average day in their introductory STEM course. The survey also included open-ended qualitative questions, asking students to briefly write about how they expected their college STEM courses to differ from their high school STEM courses, and whether or not they had any concerns about these differences. Finally, the survey included several optional demographic questions. For example, students were asked to report the highest level of education obtained by at least one of their parents.

Two surveys were developed and each distributed at a different time during the semester. A first-week survey was distributed to students during the first week of classes, and a mid-semester survey was distributed about nine weeks into the Fall semester. On the first-week survey, students were asked about their predictions of how class time will be used in their introductory college STEM courses. For example, “How do you expect the use of class time in your current science course to be different from the science courses you took in high school?” Alternatively, the mid-semester survey questions asked students about their perceptions of how class time is being used in their introductory college STEM courses. For example, students were asked “How is the use of class time in your current science course different form the science courses you took in high school?”

Data from these two time points were beneficial both individually and in comparison to one another. The first-week survey allowed us to compare the predictions of unique groups of students before they had experienced much time in the college classroom. These predictions provided insight into the expectations and concerns that students have as they enter college STEM courses. The mid-semester survey not only showed us how students’ mid-semester perceptions differed from their earlier predictions, but also how those perceptions compared to observations (performed by project personnel) of the types of instructional practices used in that classroom.

To pilot this survey, faculty members at the University of Maine (UM) and University of Nebraska-Lincoln (UNL) reached out to colleagues who were teaching introductory STEM courses in Fall 2017, asking if they would be willing to distribute the first-week and mid-semester surveys to the students in their introductory college STEM courses. Many instructors offered the survey as an extra credit opportunity for students. Responses came from 2,540 students taught by nine instructors. Courses included introductory biology (873 responses), introductory chemistry (934 responses), and introductory physics (374 responses). Biology and physics student responses came from both universities, while chemistry student data came only from UNL. All surveys were designed and distributed through the online survey tool Qualtrics (Qualtrics, 2012).

Data Cleaning and Organization

Once student responses were collected and the surveys were closed, the data were cleaned and organized. Responses were removed from the dataset if the student (1) did not agree to the consent form, (2) reported being under 18 years old, (3) left more than 50% of the content questions blank (excluding optional demographic questions), or (4) responded to the survey for the same class more than once. There were eight content questions, some with multiple parts, making a total of 14 prompts for student responses. Therefore, if students left eight or more of the prompts blank, their responses were removed from the dataset. In cases where the same student responded to the survey for the same class more than once, the response that was incomplete was removed. If neither response was totally complete, the response that was submitted first was retained. If the same student took the same survey for two different courses, for example, physics and chemistry, both responses were kept in the dataset, and coded as individual responses. Data were matched so that responses from a student who took both the first-week and mid-semester surveys were aligned. After cleaning, responses were deidentified by removing name and student ID number information, and each student was assigned a unique identification number.

Student responses to demographic questions were used to determine underrepresented minority (URM) and first-generation college student status. Student responses with any URM ethnicity option indicated (African American/Black, Filipino, Hispanic/Latino, Native Hawaiian, Pacific Islander) were categorized as URM. Student responses that indicated only options that did not fall into a URM category (Asian/Asian American, Caucasian/White) were marked as non-URM. If a student chose “other” and wrote in an ethnicity, that student's response was coded by hand into URM or non-URM status. Similar processes were carried out to determine first-generation student status from a demographic question asking students about the highest level of education obtained by at least one parent. Students who indicated that the highest level of education completed by at least one of their parents was either some high school, high school, some college, or an associate's degree were categorized as first-generation college students. Students who indicated that at least one parent had completed a bachelor's degree, master's degree, or advanced graduate degree were categorized as continuing-generation college students .

Data Analysis

After the survey data were collected, organized, and cleaned, an exploratory data analysis approach was used to identify trends and patterns in the data. Based on the literature reviewed, we suspected that demographic variables (including *first-generation student status*, *URM status*, *English language spoken at home*, *sex*, and *first-semester on a college campus*) could influence how students predicted class time in their introductory STEM courses would be spent. For example, an initial exploration was performed to examine the range of student answers given to a question asking students to predict the percent of class time they would spend on particular activities. Box plots were used to explore answer variation between students from different demographic backgrounds, and will be discussed in a later section. Preliminary statistical modeling using a linear regression model was also explored. However, the R^2 value reported from an ANOVA was 0.012, meaning that the best fitting model only accounted for 1.2% of the variation in the data. While this modeling of the preliminary data will not be discussed, a further discussion of statistical modeling of the primary data corpus is included in Chapter 3.

Classroom Observations

Another component of data collection were course observations completed using the Classroom Observation Protocol for Undergraduate STEM (COPUS) (M.K. Smith et al., 2013). COPUS is an observation tool that characterizes what both the students and instructors are doing throughout the class, in two-minute time intervals (See Figure 1). These observations allowed us to consider the alignment between student predictions, perceptions, and actual instructional practices. For each class in which students who took the survey were enrolled, at least four observations were completed (there is one exception, for which only two observations were completed. This course is not included in analysis involving observation data). Observations at the University of Maine were completed live, while classes at the University of Nebraska were video recorded and coded from the videos.

	1. Students doing													2. Instructor Doing												
min	L	Ind	CG	WG	OG	AnQ	SQ	WC	Prd	SP	TQ	W	O	Lec	RtW	FlUp	PQ	CQ	AnQ	MG	1o1	D/V	Adm	W	O	Comments:
0-2																										
2-4																										
4-6																										

	Collapsed codes	Individual codes
Instructor is:	Presenting (P)	Lec: Lecturing or presenting information
		RtW: Real-time writing
		D/V: Showing or conducting a demo, experiment, or simulation
	Guiding (G)	FlUp: Follow-up/feedback on clicker question or activity
		PQ: Posing nonclicker question to students (nonrhetorical)
		CQ: Asking clicker question (entire time, not just when first asked)
		AnQ: Listening to and answering student questions to entire class
		MG: Moving through class guiding ongoing student work
		1o1: One-on-one extended discussion with individual students
	Administration (A)	Adm: Administration (assign homework, return tests, etc.)
	Other (OI)	W: Waiting (instructor late, working on fixing technical problems)
		O: Other
Students are:	Receiving (R)	L: Listening to instructor
	Talking to class (STC)	AnQ: Student answering question posed by instructor
		SQ:: Student asks question
		WC:: Students engaged in whole-class discussion
		SP: Students presenting to entire class
	Working (SW)	Ind: Individual thinking/problem solving
		CG: Discussing clicker question in groups of students
		WG: Working in groups on worksheet activity
		OG: Other assigned group activity
		Prd: Making a prediction about a demo or experiment
		TQ: Test or quiz
	Other (OS)	W: Waiting (instructor late, working on fixing technical problems)
		O: Other

Figure 1. COPUS coding sheet, code descriptions, and collapsed code categories (M.K. Smith et al., 2013)

For the purposes of our study, an additional code was created for the COPUS data analysis entitled "Any Group Work" or "AG." For a two-minute time interval in which any of the original three group work categories were marked (Clicker Group, Worksheet Group, or Other Group), the Any Group Work category was also coded. The new "AG" code allowed for direct comparisons to be made between the percent of class time spent on any kind of group work, and student predictions and perceptions about the percent of class time spent on group work.

Preliminary Results and Editing Process

During the exploratory data analysis, student responses to a question that asked students to predict "on average, for what percent of class time do you expect to spend a) listening to lecture b) working alone c) working in groups" were analyzed. On the mid-semester survey, we asked a similar question: "On average, for what percent of class time do you spend a) listening to lecture b) working alone c) working in groups." Additionally, observation data were collected for each course, so the student predictions and perceptions could be directly compared to the actual class time spent on each of these three activities using box plots. (see Figure 2).

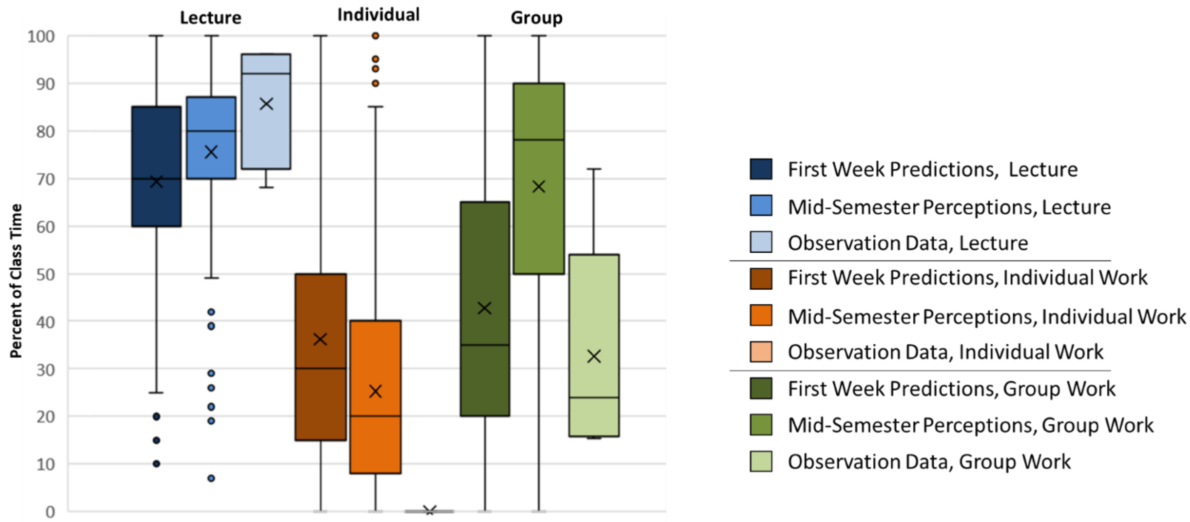

Figure 2: Pilot survey results. Comparing student predictions, perceptions, and classroom observation data for one course. (first week n = 358, mid-semester n = 355)

These box plots drew our attention to some unexpected trends in the data. For example, the survey question had not forced responses to add up to 100%, so there were a wide variety of totals among student responses. Student predictions for the percent of class time they would spend listening to lecture ranged from 10% to 100%, and predictions for the percent of class time students expected to spend working alone and working in groups both ranged from 0% to 100%. Furthermore, individual students could have predicted and reported 100% in each category, or responses in each category that added up to less than 100% all together. Additionally, students were reporting a much higher percent of class time spent working alone and working in groups than what was actually being observed in those classrooms. Therefore, we decided to look into what was causing this discrepancy. Were students interpreting these questions differently than we were?

These discrepancies between student reports and classroom observations were investigated by obtaining feedback from undergraduate students, graduate students, and faculty members on their interpretations of the survey questions. For example, a group of undergraduate learning assistants at the University of Maine took the survey as part of a homework assignment for their pedagogy seminar and their observations and interpretations of the questions during an in-class discussion were documented. Learning assistants are undergraduate students who are paid to work in large enrollment courses and assist with instruction. Learning assistants typically circulate during lecture and/or lead recitation sessions. Additionally, the Cornell Discipline Based Education Research Group, including both faculty and graduate students, discussed the survey questions and offered insight into edits and possible interpretations. After these meetings, our research group addressed the feedback by making changes to the survey. Then, the Cornell Discipline Based Education Research Group revisited the updated questions and offered another round of suggestions. Finally, graduate students, faculty, and staff participants in the Maine Center for Research in STEM Education weekly group meeting at the University of Maine gave feedback on the updated versions of the survey questions.

Each of these groups offered unique perspectives and suggestions on the survey questions. For example, comments from the Cornell lab group led us to be more specific when asking about a particular portion of the course. The survey was meant to gather information from students about the "lecture" portion of their course only, not recitation or laboratory sections. Perhaps the reason students were reporting such a high percentage of class spent working in groups, compared to what was actually observed, is that they were thinking about lab, recitation, or study groups when answering survey questions. The undergraduate learning assistants agreed that they were thinking about the course as a whole, rather than just the "lecture" portion, when answering these questions. Therefore, a note was added at the beginning of the survey specifying which course meeting students should be thinking about while completing the survey (See Table, A.1, Row B). We also made each question specific to the course, and specified the days and times of these meetings. For example, *"think about the portion of your BIO 100 course that meets on MWF from 9:00 to 9:50."*

Other feedback concerned the perspective of the questions. For example, the Fall 2017 surveys asked for what percent of class time "Students listen to lecture" while the Fall 2018 surveys asked about the percent of class time “The instructor lectures to the students.” The undergraduate learning assistants explained that they had answered the questions based on what they thought actually happened in class, not what they were expected to do. Regarding the question that asked students to report the percent of class time that “students listen to lecture,” one learning assistant explained, “There is a difference between ‘professor lecturing’ and ‘students listening to lecture.’” This student expressed that the question was phrased in a way that probed whether or not students were paying attention, rather than what was expected to be happening in class. Based on feedback like this, the focus of the questions was changed from the students to the instructor. Changing the perspective focused the research on how class time is meant to be spent, instead of the commitment level of particular students to these activities.

Another change on this question stemmed from a concern that listening to lecture, working alone, and working in groups did not encompass everything that occurred during a given class period. Therefore, a fourth “other” option was added to this question. Additionally, we added descriptions to each option (listening to lecture, working in groups and working alone) in order to provide examples of what each activity might look like in class (Table A.1 Row C). Adding the “other” option also led us to force student answers to this question to add up to 100%. Including the “other” option allowed these four behaviors to cover any activity that goes on in the classroom, therefore reasonably totaling 100%. This way, all answers would have a constant maximum. A follow-up question was also added, which asked students to explain where they got the information they used to make their predictions about the percent of class time that would be spent on each type of activity (Table A.1 Row D). Student responses to this new question gave us insight into the types of sources students used to make predictions about how class time would be spent in their college courses, such as information given on the first day of class, high school guidance counselors, or parents.

More detailed descriptions and explanations were also added in other places throughout the survey. For example, some questions in the survey referenced clicker questions, but the undergraduate learning assistants pointed out that some of the instructors used similar techniques with tools other than clickers (*TopHat*, colored notecards, *etc.*). Here, a description of what was meant by "clicker question" helped clarify the prompt. Descriptions were also added to places where questions mentioned "active learning," a term with which students may not be familiar (*e.g.,* Table A.1, Rows F, G).

Edits were also made to other questions on the survey. For example, on the Fall 2017 survey, students were asked a question with a 5-category Likert scale to predict how often they would see particular behaviors occur in the classroom on a scale from "Never" to "A couple times per class." The behaviors in this question were directly linked to COPUS observation codes, and during analysis, we realized that with 4-6 observations per class, we could not draw conclusions about these behaviors on such a specific scale. Therefore, the options were changed on this question to a three-point scale that includes "Never," "Occasionally," and "Frequently." We were able to more directly compare these answers with actual observation data (Table A.1, Row E).

After student responses to the open-ended qualitative questions on the pilot survey were coded and categorized, they were rewritten as multiple-choice questions. Students gave a wide range of answers to these open-ended questions, so categories of common student answers were identified, and reworked into new styles of questions for the Fall 2018 survey. In Fall 2017, one open-ended question asked students to describe how they thought their college STEM course would differ from the similar course they took in high school. In Fall 2018, the question was adjusted so that students could rate a number of activities as occurring "less than," "about the same as," or "more than" in the high school versions of that course (Table A.1 row H). Similarly, a different question on the Fall 2017 survey asked students to write about any concerns they had about their college STEM courses. After coding and organizing these student concerns, a list of the most common was added to a new type of question on the Fall 2018 survey. Students were asked to organize these common concerns into categories titled "I am very concerned about…, "I am somewhat concerned about…," and "I am not concerned about…" (Table A.1, Row G)

Some changes were also made to the demographic questions, including the addition of questions about international and transfer student status, and adjusting the Race/Ethnicity options to match the US Office of Management and Budget categories (https://www.whitehouse.gov/omb/). We also added questions based on further feedback and suggestions committee members and collaborators, including a question about the students' likelihood to graduate with a STEM major (See Appendix B.2). This data-driven approach to survey editing led to a more complete and clear set of questions, which we were able to distribute for a more robust round of data collection in Fall 2018 (see Chapter 3).

CHAPTER 3

FALL 2018 DATA AND ANALYSIS

Overview

In order to more fully understand the high school to first-year college instructional transition, revised versions of the surveys were distributed to students at three institutions in Fall 2018. A first-week survey was distributed during the first week of classes in the fall, asking students about their predictions about the types of instructional practices they would see in their introductory STEM courses. A mid-semester survey was distributed 6-8 weeks into the semester, asking students about their perceptions of the types of instructional practices being used in these classrooms. Additionally, classroom observations of five class meetings early in the semester were completed in each course using COPUS. These classroom observations allowed researchers to consider the alignment between student predictions about instructional practices and the actual instructional practices being using in those courses. Demographic data were also collected from the surveys, and was used to address research questions regarding how the predictions held by students from different demographic backgrounds may differ. Statistical analysis was performed in order to determine whether a particular set of demographic variables was best able to describe the variation in student predictions. This chapter will explain in detail the methods for collecting and analyzing the survey data, in addition to the results about the predictions of incoming STEM students.

2018 Methods

Fall 2018 Data Collection

During Fall 2018, surveys were distributed at the University of Maine (UM), University of Nebraska (UNL) and Cornell University (CU) (Appendix B). The first-week survey was distributed during the first week of classes at the three institutions, and the mid-semester survey was distributed between weeks 6 and 8. Responses came from 1952 students enrolled in introductory STEM courses taught by 20 instructors. Overall survey response rate before cleaning was 62% for the first week survey, and 42% for the mid-semester survey. Course subjects included biology, chemistry, computer science, earth science, ecology and environmental science, economics, engineering, forestry, mathematics, physics, and statistics. For each course in which students responded to the survey, the first six class meetings were observed and recorded, and coded using COPUS. Student response data were generally cleaned and organized in the same way as the Fall 2017 data. However, for the purposes of statistical analysis, some changes were made to the methods outlined in Chapter 2. Our goal was to use the largest trusted dataset for analysis. For example, if student completed the survey for more than one class, the same ID number was used for both responses. Using the same ID number will allow us to investigate differences between student predictions about classes in various subjects in later analyses. For the current analyses, one survey response for each of these students was selected to include in statistical analyses to allow for data rows that were all unique. Additionally, students who left any of the content or demographic questions blank, or chose "prefer not to answer" were removed from the dataset. For matched students who answered both surveys, those who changed their answer for demographic questions from the first-week to the mid-semester survey were removed from the dataset. If a matched student left a demographic question blank on one survey, but answered it on the other survey, their answer was filled in to match on both surveys. This left a dataset for analysis that included complete responses from 1549 students on the first-week survey, and 1229 on the mid-semester survey.

Data Analysis

Statistical modeling was used in order to determine whether a particular set of demographic variables could be used to explain the variation in student responses to a question asking about the percent of class time that would be spent on a variety of activities (See Appendix B.1, Q6). Due to the potential of multi-level regression models common in the education field, we followed the recommendations for analysis outlined by Elli Theobald (Theobald, 2018). The statistical analysis programming environment “R” was used for modeling, with guidance from the procedures outlined in Theobald, 2018 (R Core Team, 2013; Theobald, 2018). First, the associations between potential categorical predictors were measured using Goodman Kruskal τ. Then, potential demographic predictor variables were put into a linear regression model using the R package lme4 (Bates, Maechler, & Bolker, 2015). In order to select fixed effects, the R package “MuMIn” was used which uses Akaike Information Criterion (AIC) to select the best fitting model (Barton, 2018). AIC corrects for sample size when determining the best fitting model (Theobald, 2018). The best fitting model output was compared to a null model that only included the random effect. The best fitting model was further analyzed using ANOVA and marginal means, using the car and emmeans packages in R (Fox & Weisberg, 2011; Lenth, 2018).

2018 Results

First-Week Survey Results

During the 2017 pilot study, wide variation among student responses in Figure 1 was one reason researchers worked to update the survey questions. In order to see if the changes to the survey question helped these issues, student response data from the 2018 version of the same question were analyzed (Table A.1, Row C). Comparing Figure 1 to Figure 3, it can be observed that there is much less variation in the 2018 data, especially in the Group Work and Individual Work categories. Forcing student answers to add up to 100% allowed us to see the trends much more clearly.

Students predict that most of class time in their college STEM courses will be spent listening to lecture

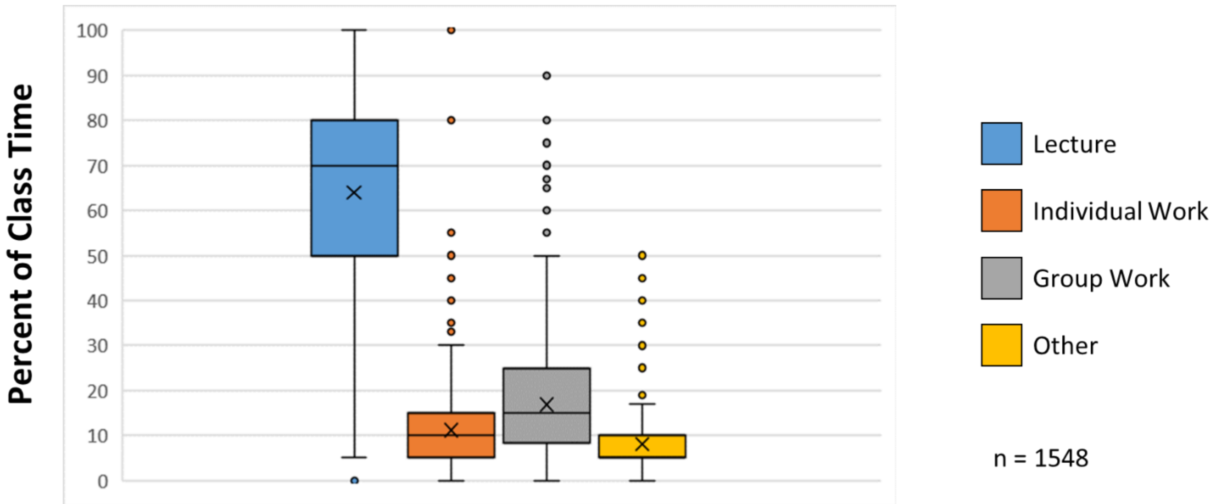

Figure 3. Overall first-week student predictions. Box and whisker plots showing the variation of student predictions about the percent of class time in introductory STEM courses that will be dedicated to lecture (blue), working alone (orange), working in groups (gray), or doing other things (yellow). The lines represent the median, “x” represents the mean, and data points not included in more than 1.5 times the interquartile range are represented as dots.

The overall first-week data showed that students generally predicted that most of their class time would be spent listening to lecture (Figure 3). Specifically, the median prediction was that 70% of class time would be spent listening to lecture, 10% of class time spent on Individual Work, 15% of class time spent on group work, and 5% of class time spent on “Other.” Predictions for lecture were the most varied, with responses ranging from 5% - 100%, and an interquartile range from 50% to 80%. Group work is the next highest and most varied activity, and individual work is the lowest and least varied of the three activities. These results focused our attention on lecture, as we were interested in the wide variation in responses, and whether any of this variation could be accounted for by differences in predictions of students from different demographic backgrounds.

Continuing-generation college students predict more lecture than first-generation college students

Based on the literature and our research questions, we were particularly interested in the responses of both first-generation college students and students who were taking classes on a college campus for the first time. Therefore, the predictions of these groups of students were compared (Figure 4, 5). The results showed that first-generation students predicted less time would be spent listening to lecture in their college STEM courses compared to their continuing-generation counterparts. The median prediction for first-generation college students was that 60% of class time would be dedicated to lecture. The median prediction for continuing-generation college students was that 70% of class time would be dedicated to lecture. A student's t-test showed that the difference between these two groups is statistically significant ($p < 0.05$).

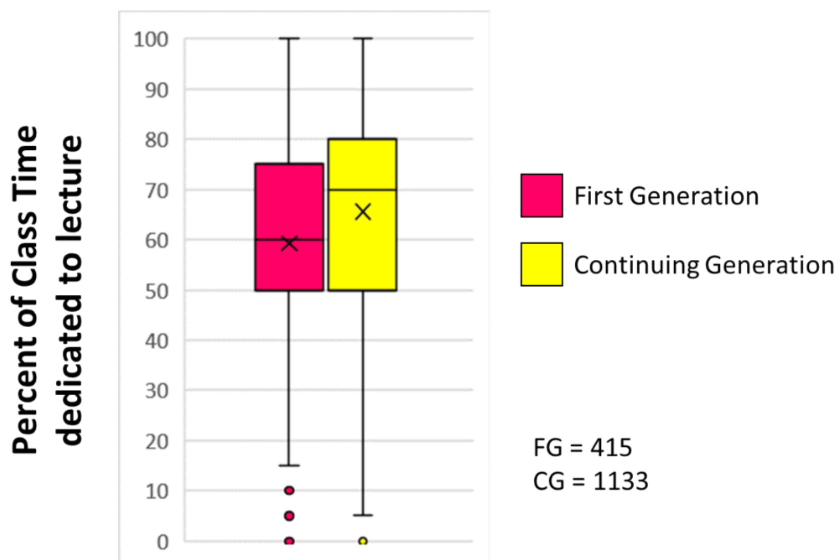

Figure 4. Predictions of first-generation and continuing-generation students. Box plots representing the variation in predictions about the percent of class time spent listening to lecture between first-generation (pink) and continuing-generation (yellow) students.

First-semester college students predict less lecture than students returning to campus

Figure 5 shows that students who were taking classes on a college campus for the first time predicted that less class time would be spent listening to lecture compared to students who were returning to college. The median percent of class time students predicted would be dedicated to lecture was 60% for first-semester students and 70% for returning students. A student's t-test showed the difference between the predictions of these two groups to be statistically significant ($p < 0.05$). The data from the first-semester students were less varied than the responses from the returning students, with an interquartile range of 25% compared to 30%.

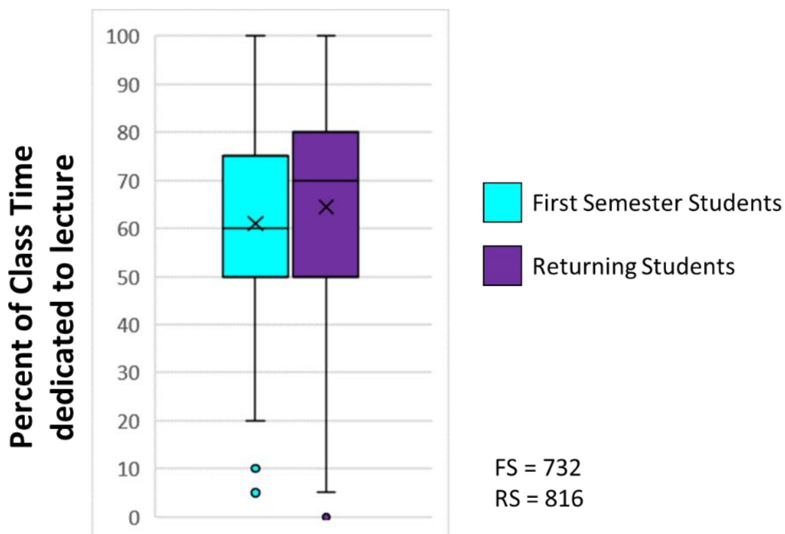

Figure 5. Predictions of first-semester and returning students. Box plots representing the variation in predictions about the percent of class time spent listening to lecture, comparing students taking classes on a college campus for the first time (teal) and students returning to college (purple).

The overall trends between demographic groups are also seen at the course level

The trends seen at the overall level were visible on the course level as well. Figure 6a shows the differences in student predictions about the percent of class time that would be spent listening to lecture in each class. The y-axis represents the difference between the predictions of the continuing-generation students compared to the first-generation students. (Continuing – First). Therefore, if the y-value is positive, it means that the particular course follows the overall trend, and the continuing-generation students predicted more lecture than the first-generation students. If the y-value is negative, it means that the first-generation students in that class predicted more lecture than the continuing-generation students. 65% of the individual classes followed the overall trend. The x-axis represents the observed percent of class time spent lecturing in that particular course, obtained from the COPUS classroom observation data.

Figure 6b shows the same trend, but compares the predictions of first-semester students to returning students on the class level. Here, the y-value represents the difference between the predictions of the returning students and the first-semester students (Returning – First-semester). 79% of individual class data follow the overall trend.

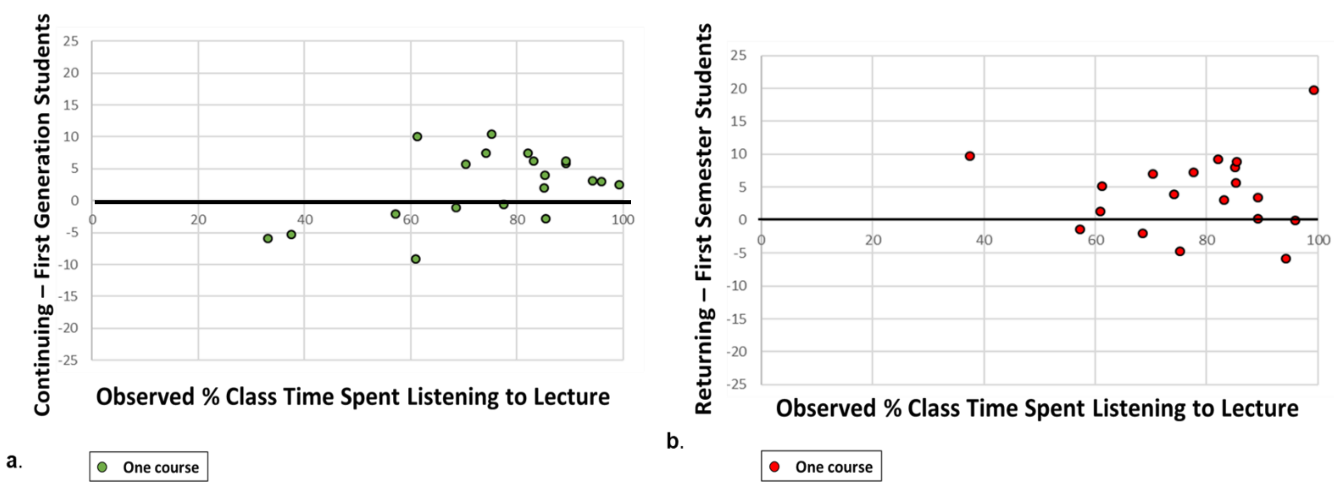

Figure 6. Course-level trends on the first-week survey. Plots of mean differences between demographic groups in predictions about class time dedicated to lecture at the class level. Y-values are the differences between the average predictions of the two groups in that class. X-value is the average of the time spent lecturing from all of the observations in that class. **a.** First-generation compared to continuing-generation students: y-axis represents (predictions of continuing-generation students – predictions of first-generation students) in each class. **b.** First-semester students compared to returning semester students: y-axis represents (predictions of returning students – predictions of first-semester students) in each class.

<u>The best fitting linear regression model includes both first-generation student status and first-semester student status as significant predictors:</u>

In order to determine whether a particular set of demographic variables was able to explain the variation in student predictions about the percent of class time that would be dedicated to lecture, statistical modeling was used. First, correlations between categorical variables were measured using Goodman Kruskal τ. These variables included *course size*, *course subject*, *institution*, *instructor, sex*, *transfer student status*, *English language spoken at home*, *international student status*, *first-semester on a college campus student status*, *current class standing*, *first-generation student status*, *and URM status*. High correlations (values greater than 0.3) were found between *course subject* and *course size*, *course subject* and *institution*, and *course subject* and *instructor*. Given these high correlations and the unbalanced subject populations, *course subject* was removed from the model, to be investigated in future studies. High correlations were also found between *current class standing* and *first semester on a college campus student status*. *Current class standing* was removed from the model, as we were most interested in differences between students who were new to campus and students who were returning to campus, as opposed to the university-assigned class standing of the students. High correlations were also found between *instructor* and *institution,* and *instructor* and *course size*. However, we were interested in the interactions among these three variables and how they might lead to future research directions, and decided to retain them in the model. The high correlations only reduced the power of the highly correlated predictors themselves.

Fixed Effects	Estimate	Std. Error	t-value
(Intercept)	66.09	4.92	13.44
Medium Course Size	-22.48	5.11	-4.4
Small Course	-22.05	6.27	-3.52
Continuing Generation	3.17	1.09	2.92
Returning Student	4.43	0.98	4.5

Table 1. Linear Regression Best Fitting Model. This table shows the fixed effects included in the best fitting linear regression model. The estimates for each fixed effect show the difference between the that group and the intercept reference group. For example, continuing-generation students predicted 3.17% more lecture than the reference group. Here the reference group represents the mean response from students enrolled in large courses, who are both first-generation and first-semester college students. In general, t-values greater than 2 are significant.

With student predictions about the percent of class time dedicated to lecture as the dependent variable, the retained variables were put into a linear regression model. A likelihood ratio test was used to determine whether the best fitting model was significant. The full final model was found to be significant compared to a null model that only included the random effects (*instructor* and *institution*) with a p-value of 1.407×10^{-8}. The R^2 value for the best fitting model was 0.38, meaning that the best fitting model explained about 39% of the variation in the data. The full final model represents the set of predictor variables that are best able to describe the variation in the data (Table 1). In the best fitting model, the predictors included were *first-generation student status*, *first-semester on a college campus student status*, and *course size*. So, even when compared to all of the other demographic variables, the best fitting model showed that first-generation student status and whether or not this was a student's first-time taking classes on a college campus were important predictors of a student's response.

Taking all of the predictors into account, we can see in our best fitting model that continuing-generation students predicted that about 3% more of class time would be spent listening to lecture compared to their first-generation student peers. Similarly, students who were returning to a college campus predicted about 4% more class time to be spent listening to lecture than first-semester students.

Predictor	Chi Square	DF	PR(>chi sq)
First Generation	8.5075	1	0.003537***
First Semester	20.2447	1	6.814e-06**
Course Size	20.7066	2	3.189e-05***

Table 2. Output from an Analysis of Variance Table, using Type II Wald Chi Square Tests. Outputs tell the significance of each predictor through a likelihood ratio chi square test. The further the chi square is from zero, the more likely there is a significant difference between the two groups. For example, a chi square value of 8.5 and a PR-value of 0.003537 means that that the predictions of first-generation college students are statistically significantly different than those of continuing-generation college students. (Significance Codes: 0 "***", 0.001 "**")

Analysis of variance tables (ANOVA) were used (using the car package in R) to determine whether significant differences existed between the groups within the predictor variables in the best fitting model (Table 2). The ANOVA output is a likelihood ratio chi square test. The further the chi square value is from zero, the more likely the predictor variables contribute to significant variation in the dependent variable. It was confirmed that these predictors were significant (p-values < 0.05).

Mid-Semester Survey Results

<u>Overall trends of the mid-semester survey are similar to the first-week survey</u>

In the overall mid-semester survey data, the general trends look similar to the first-week survey data. Students are reporting that most of the class time in their introductory STEM courses is spent on lecture, with a median report that 70% of class time is dedicated to lecture. Again, lecture shows the widest range of student answers (5% - 100%) and the largest interquartile range (50% to 81.5%). The median student reports for the other activities were 5% of class time for individual work, 15% of class time for group work, and 5% of class time on "other" activities.

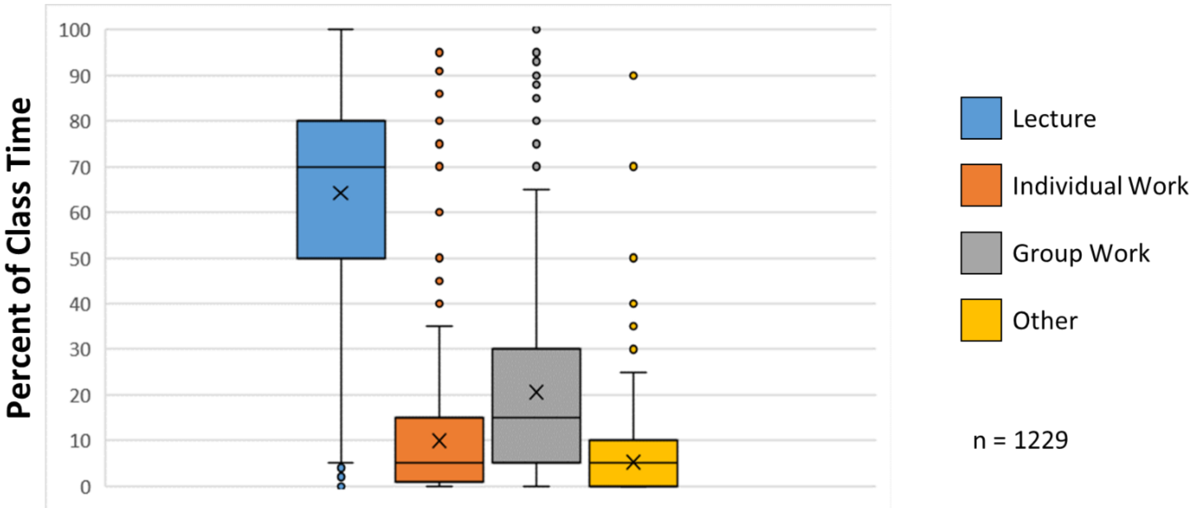

Figure 7. Overall mid-semester student perceptions. Box and whisker plots showing the variation of student perceptions of the percent of class time in introductory STEM courses dedicated to lecture (blue), working alone (orange), working in groups (gray), or doing other things (yellow).

<u>First-generation students report less lecture than continuing-generation students, but gap narrows compared to predictions</u>

The reports of first-generation students and continuing-generation students about the percent of class time dedicated to lecture are compared in Figure 8. The median percent of class time reported by continuing-generation students was 70%, which is the same as their prediction (Figure 4). However, first-generation students shifted from a median of 60% on the first-week survey to 65% on the mid-semester survey, narrowing the gap between the two groups of students.

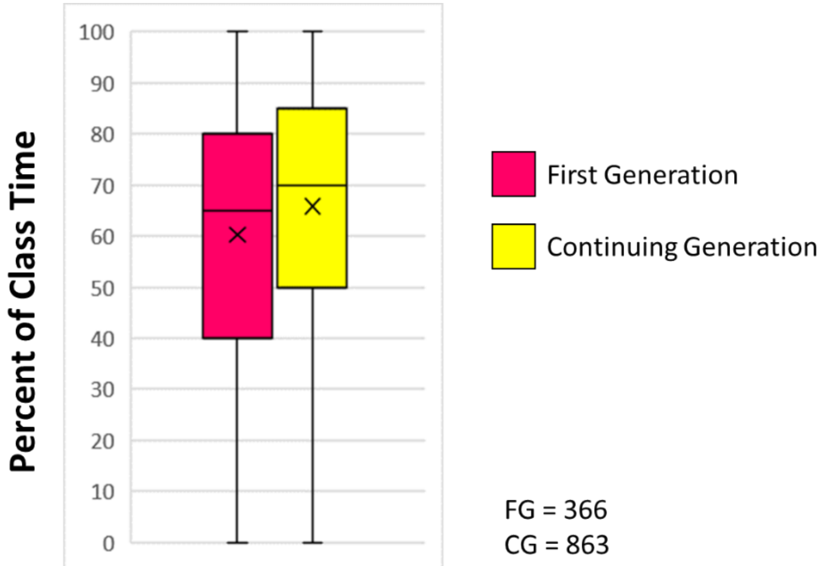

Figure 8. Perceptions of first-generation and continuing-generation students. Box plots representing the variation in perceptions of the percent of class time spent listening to lecture between first-generation (pink) and continuing-generation (yellow) students.

First-semester students and returning students report similar amounts of class time dedicated to lecture

Figure 9 shows how the perceptions of first-semester students compared to those of returning students about the percent of their course that is dedicated to lecture. Returning students and first-semester students reported that a median of 70% of class time was dedicated to lecture.

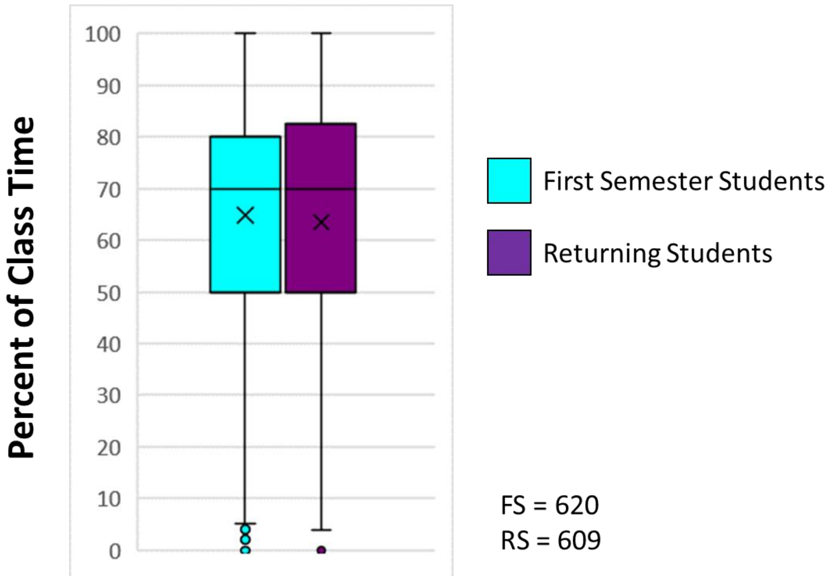

Figure 9. Perceptions of first-semester and returning students. Box plots representing the variation in perceptions of the percent of class time spent listening to lecture between students taking classes on a college campus for the first time (teal) and students returning to college (purple).

<u>Median values for first-generation and first-semester students shift towards those of continuing-generation and returning students</u>

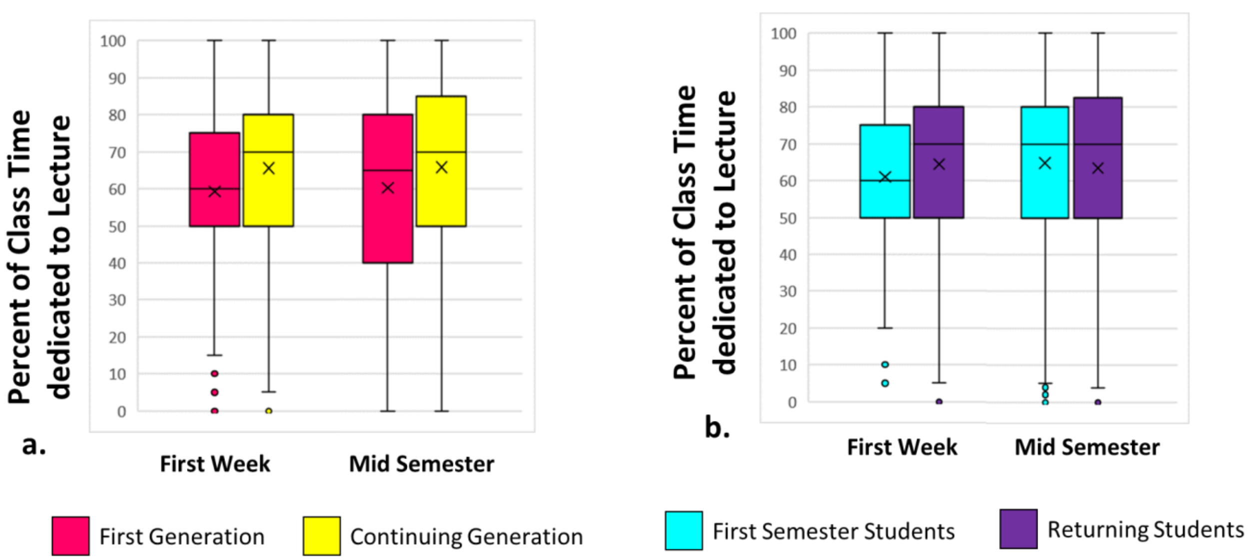

Figure 10. Side by side student predictions and perceptions. Box plots representing the variation in student responses concerning the percent of class time spent listening to lecture across the first-week and mid-semester surveys. **a.** Predictions and perceptions of first-generation (pink) and continuing-generation (yellow) students. **b**. Predictions and perceptions of first-semester students (teal) and returning students (purple).

Figure 10a shows that the median prediction and perception of continuing-generation students about the percent of class time dedicated to lecture did not shift, and stayed at 70% for both surveys. However, the median prediction of first-generation students at 60% shifted to a perception of 65%, narrowing the gap between the two groups of students. A similar trend is visible in Figure 10b. The median prediction and perception of returning students were the same, at 70%. However, the median prediction for first-semester students was 60%, which shifted to meet the returning students' perceptions, also at a median of 70%, closing the gap between the two groups.

<u>At the course level, the differences between these demographic groups are reduced on the mid-semester survey</u>

To see if these gaps narrowed at the class level as well, the differences between the average perception of the first-generation and continuing-generation students in each class were compared. Figure 11 shows that in 55% of classes, first-generation students perceived more lecture than continuing-generation students. In 5% of classes, there was no difference in the perceptions of the two groups, and in 45% of classes, continuing-generation students perceived more lecture than first-generation students. Figure 11b shows that in 58% of classes, first-semester students perceived more lecture than returning students, in 5% classes there was no difference in between the two groups, and in 37% of classes returning students perceived more lecture than first-semester students. When Figure 11 is compared to Figure 6, it can be seen that the differences between these two groups are reduced in the mid-semester survey.

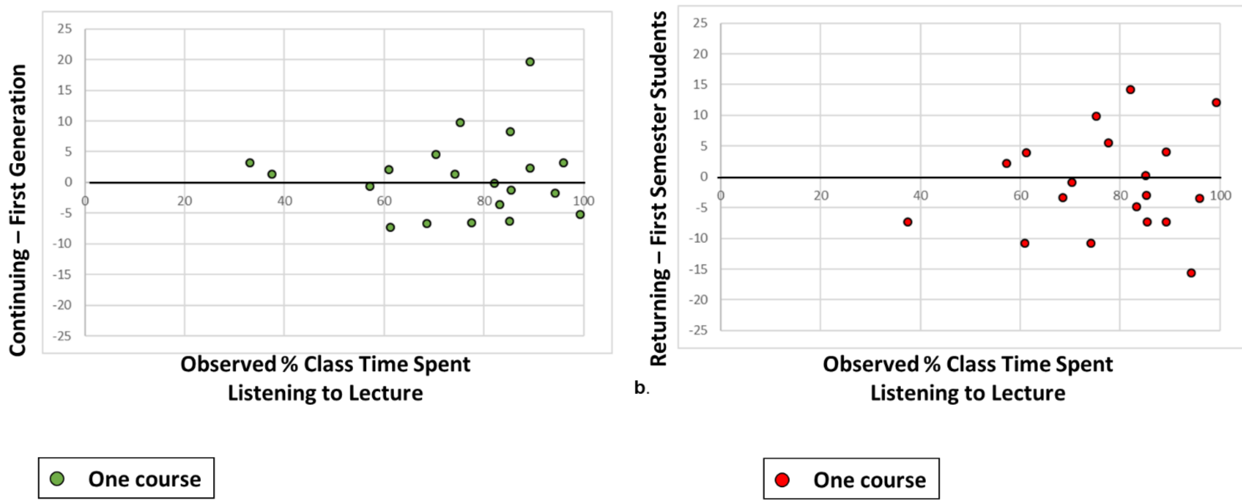

Figure 11. Course level trends on the mid-semester survey. Plots of mean differences between demographic groups in perceptions about class time dedicated to lecture at the class level. Y-values are the differences between the average perceptions of the two groups in that class. X-value is the average of the time spent lecturing from all of the observations in that class. **a.** First-generation compared to continuing-generation students: y-axis represents (perceptions of continuing-generation students – perceptions of first-generation students) in each class. **b.** First-semester students compared to returning semester students: y-axis represents (perceptions of returning students – perceptions of first-semester students) in each class.

Observation Data

<u>All students are underpredicting lecture, especially first-generation and first-semester students</u>

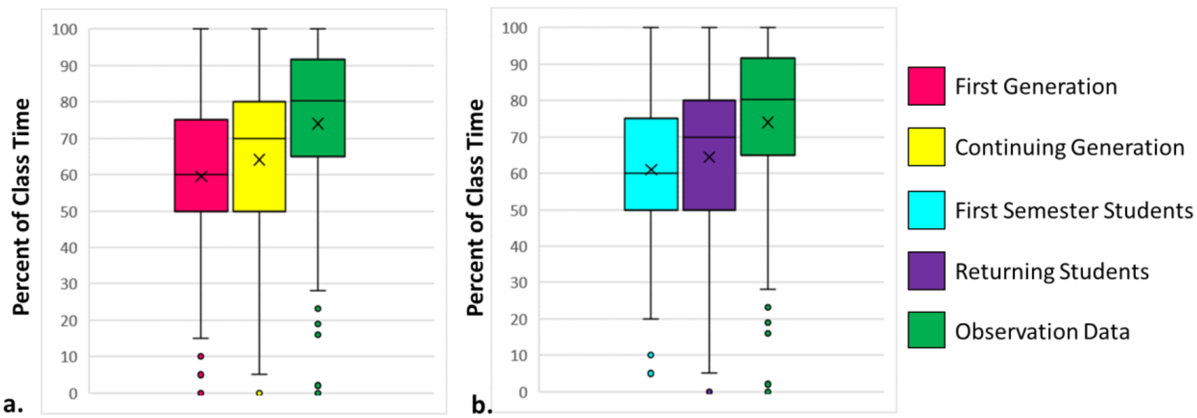

Figure 12. Students underpredict the percent of class dedicated to lecture. Box plots representing the variation in student predictions about the percent of class time that would be dedicated to lecture and observations of the percent of class time actually dedicated to lecture. **a**. Comparing first-generation (pink) and continuing-generation (yellow) student predictions to observation data (green). **b**. Comparing first-semester (teal) and returning student (purple) predictions to observation data (green).

In addition to survey data, observation data from the COPUS were collected for each class, and aggregated in a box plot to show the variation in percent of class time dedicated to lecture observed across classes (Figure 12). Figure 12 shows that all students underpredicted the amount of time dedicated to lecture in college STEM courses. Specifically, first-generation students and students taking classes on a college campus for the first time predicted even less than their peers. Of the 105 classroom observations completed, the median percent of class time instructors spent lecturing was 80%. Continuing-generation and returning students predicted a median of 70% of class time to be spent listening to lecture, and first-generation and first-semester students predicted 60% of class time to be spent listening to lecture.

CHAPTER 4:

DISCUSSION

Revisiting the Research Questions

This study investigated the instructional transition of STEM students between their high school and first-year college STEM courses. Two surveys were distributed to students enrolled in introductory STEM courses during the fall semester at three large universities, one private and two public. The data from these surveys allowed us to learn more about the expectations and experiences of these incoming students. Classroom observation data were compared with these survey responses in order to explore how well student predictions aligned with actual instructional practices. The research questions driving this investigation were the following: (1) What types of instructional practices do students predict when entering college? (2) Do those predictions vary by student demographics? and (3) Do differences in predictions between students from various demographic backgrounds persist through to mid-semester perceptions? Surveys distributed to students during the first week of classes and midway through the semester allowed for an analysis of student predictions and perceptions.

What types of instructional practices do students predict when entering college?

The results from the first-week survey showed that although there was a wide range of student predictions about the percent of class time that would be dedicated to lecture, students generally predicted that most of their class time would be spent listening to lecture (Figure 3, p. 28). Specifically, the median prediction about the percent of class time dedicated to lecture was 70%.

Do predictions about instructional practices vary by student demographics?

Previous research has shown that students from different demographic backgrounds, such as first-generation college students, have unique experiences and struggles with the high school to first-year college transitions (Cataldi et al., 2018; Chen & Carroll, 2005; Padgett et al., 2012; Stephens, Fryberg, et al., 2012; Terenzini et al., 1996; Yee, 2016). Therefore, we expected that the predictions of first-generation college students would differ from those of continuing-generation college students. Using descriptive and inferential statistics, we found that first-generation college students predicted that less time would be dedicated to lecture compared to continuing-generation college students (Figure 4, p. 29).

Additionally, previous research had shown that students experience a major change in instructional practices between their high school to first-year college STEM courses (Akiha et al., 2018). Therefore, we were interested in comparing the predictions of those students who were taking classes on a college campus for the first time to those who were returning to campus. The results indicated that students who were taking classes on a college campus for the first time predicted less lecture than students who were returning to campus (Figure 5, p. 30). These trends were not only present in the overall dataset, but in most of the individual courses as well (Figure 6, p. 31).

Do differences in predictions between students from various demographic backgrounds persist through to the mid-semester perceptions?

Results from the mid-semester survey showed that differences seen between the predictions of first-generation and continuing-generation, and between first-semester and returning students, were reduced in their perceptions after instruction (Figure 10, p. 37). The perceptions of the various groups of students were more well aligned than predictions between the groups. Additionally, the median predictions of continuing-generation students and returning students matched the median values of their perceptions. However, the median perceptions of the first-generation and first-semester students were higher than the medians of their predictions. These trends were also seen at the course level, where a clear pattern of one group consistently perceiving more or less lecture than another was not observed (Figure 11, p. 39). The reduced variation between groups shows that the common experiences of students in their college STEM courses may be mitigating the impact of demographics on student perceptions.

Expectancy Violation Theory

A lens through which to investigate the interactions between student predictions, student perceptions, and instructional practices is Expectancy Violation Theory (Burgoon, 1978). Expectancy Violation Theory was originally developed in studies of psychology about personal space, and has been used in education research as a framework to examine the implications of student expectations (Brown et al., 2017). The theory suggests that when an event is different than was predicted, expectations are violated, which may impact one's experience. For example, if a student predicts that a class will include a particular set of instructional practices, but in reality it does not, that student's expectations are violated. In this thesis, Expectancy Violation Theory is relevant because student predictions about the percent of class time that would be dedicated to lecture were different from the percent of class time observed to be spent listening to lecture in those courses. The results showed that all students underpredicted the percent of class time that would be dedicated to lecture (Figure 12, p. 40). Furthermore, first-generation and first-semester students predicted even less lecture than their peers. Figure 12 shows that student expectations are being violated by experiencing more lecture than was predicted.

Notably, Expectancy Violation Theory is typically discussed in literature concerning student *resistance* to active-learning instructional practices (Keeley, 2014; Seidel & Tanner, 2013). For example, instructors who wish to add more active learning to their course often express concern about violating their students' expectations of what a "typical" college course should look like (*i.e.,* predominantly lecture). Conversely, survey data collected in this study suggest that faculty in introductory courses are violating student expectations by lecturing *more* than is expected. Less class time spent dedicated to lecture and more class time spent on active learning activities would more closely align with student expectations about their introductory college STEM courses.

A separate survey question asked students to predict the combination of lecture and active learning that they thought would be best for their learning (Table B.1, Q9). The results showed that students thought that a median of 60% of class time spent listening to lecture and 40% of class time spent on active learning would be best for their learning. Figure 14 shows that these opinions are not well aligned with actual teaching practices. While students believed that 60% of class time will be best for their learning, they predicted an increased amount of class time to be dedicated to lecture (a median of 65%). The median percent of class time dedicated to lecture reported in both student opinions and predictions were below the median of 80% of class time actually dedicated to lecture in the observed introductory STEM courses.

Previous studies have shown that the high percentage of class time spent dedicated to lecture at the three institutions involved in this study is common (Stains et al., 2018), despite the fact that much research has shown active learning teaching strategies to be more effective for student learning (Freeman et al., 2014). Additionally, students who switch out of Science, Math, and Engineering majors often cite the types of instructional practices used in introductory courses when asked about their reasons for leaving (Seymour & Hewitt, 1997). Therefore, the large amount of lecture is not only violating student expectations and personal opinions about what is best for their learning, but it may be impacting their learning experiences and educational goals.

How Can Student Survey Data Inform the Instructional Practices Used in Introductory STEM Courses?

This project has investigated the predictions and perceptions held by students enrolled in introductory STEM courses. Through the data collected, it is clear that student predictions are not always well aligned with instructional practices, and that differences exist between the predictions of students from various demographic backgrounds. However, it is important to consider how these data can be used to promote change in introductory STEM courses. One step is to publish the research findings, which will provide important information for the field. However, when making decisions about teaching, faculty tend to over-rely on their personal experiences working with particular students, such as memories of talking with individual students about their misconceptions, rather than on experimental evidence (Andrews & Lemons, 2015; Hora, Bouwma-Gearhart, & Park, 2017). Additionally, many first-year college instructors do not get information about the demographics in their class and various factors that influence this transition for students. Also, while many faculty care about student thinking and want to explore data (Hora *et al*., 2017), few have personal or institutional systems that support their attempts. Rather, most faculty deal with data on their own without collaboration from colleagues or experts (Hora et al., 2017).

Therefore, another approach to data dissemination is to develop Faculty Learning Communities. An FLC is a small group of faculty who meet regularly over the course of a year to discuss and reflect on a common goal (Cox, 2004). Cohort-based FLCs are groups of peer faculty or staff who meet regularly to address the needs of teaching, learning, or development relevant and important to the group. A topic-based FLC addresses a specific issue or concern, and faculty work together to discuss and design solutions to the problem. The structure of FLCs align with criteria for successfully facilitating change in STEM instruction (Henderson, Beach, & Finkelstein, 2011). In a study that investigated the outcomes of FLCs at six universities, researchers relied on self-reports from FLC members to determine how participation in the FLC influenced their teaching (Beach & Cox, 2009). Another study collected data about student learning using pre- and post-instruction assessments, but again relied on reports from faculty to determine how the FLC had influenced their teaching (Elliott et al., 2016). Comparatively, professional development frameworks that include an iterative, data-driven approach to change have been shown to be successful at informing instructional practices and improving student learning (Pelletreau et al., 2018).

For this project, topic-based FLCs have been developed that focus on the high school to first-year college instructional transition, the factors that can influence this experience for students, and the unique experiences of particular groups of students, such as first-generation college students. FLCs at all three institutions involved in this study started meeting in Fall 2018. To date, they have spent time analyzing student survey data emerging from this project, reviewing literature about evidence based teaching practices, discussing the first-year experience with school administrators, and exploring research about the high school to first-year college instructional transition. The FLCs will continue to meet throughout the academic year and will work toward the development of strategies, materials, and other resources that can be used in introductory STEM courses, as well as addressing the questions and concerns of students. While the work of the FLCs is ongoing, we anticipate that the differences in expectations and perceptions highlighted by the current investigation will guide conversations about increasing the alignment between expectations and experiences, and minimizing expectancy violations.

Future Directions

The surveys developed as part of this project provide a rich opportunity for future investigations that can also serve to help STEM students more successfully navigate the transitions from high school to college. The next step is to analyze student responses to other questions on these surveys. For example, we will look for demographic differences in student predictions and perceptions about the percent of class time spent dedicated to group work and individual work. We will also look at a question that asks incoming students to rank various concerns they hold about their college STEM courses (Table B.1, Q12). Analyzing data about concerns will allow us to see whether student demographics influence the types or frequency of concerns held by students. We will also continue our analysis of the mid-semester survey data. For example, data were collected from questions asking students to report how often particular instructional practices are used in their courses. Comparing these student perceptions to COPUS observation data will allow us to explore how student perceptions align with actual instructional practices. These next steps will lead to a more complete understanding of the predictions and perceptions held by incoming students.

Future investigations will also explore the extent to which particular patterns in student responses are linked to their plans to persist in a STEM major. Specifically, we will investigate whether this expectancy violation is linked to retention. For example, we can explore whether or not students whose predictions were more closely aligned with teaching practices were more likely to persist in STEM majors than those whose predictions were less well aligned. To begin to address this question, we included survey questions that asked students to report how likely they were to graduate with a STEM degree in the future (Table B.1, Q25; Table B.2, Q26). First, we can group student responses by their likelihood to graduate with a STEM major, and whether that likelihood increases, decreases, or remains the same between the first-week and mid-semester surveys. Then, we can compare how the predictions and perceptions of students in these groups compare. We can also examine whether those who show a decreased interest in pursuing a STEM major have predictions that are more similar to or different from classroom observation data than those of their peers.

In addition, future studies could explore whether variables beyond student demographics influence student predictions and perceptions about instructional practices. For example, it would be interesting to explore how variables such as course size or course subject influence student expectations and experiences. Research questions could target topics such as whether students in large enrollment courses predict more lecture than students in small enrollment courses, or whether students predict different instructional practices in mathematics courses compared to physics courses. These explorations could be achieved by looking at overall course-wide data in different subjects and examining prediction differences of students who are taking multiple courses at the same time (*i.e.,* does a student answer the survey questions differently when thinking about BIO100 versus MATH100?).

Additional factors, such as student participation in a bridge program, could also be considered. Many institutions have implemented summer bridge programs to help prepare students for their first year of college academics. These are most often academic programs designed to help incoming college students prepare for the rigors of college content, studying, and courses in general. Therefore, whether or not students have participated in one of these programs may impact the expectations and experiences they hold about their college STEM courses. Researchers found that participation in a summer bridge program that specifically targeted populations that are underrepresented in STEM majors and fields made those students more likely to persist to at least their third year of school, and for some groups increased course grades and sense of belonging (Tomasko, Ridgway, Waller, & Olesik, 2016). Other programs like these, such Emerging Scholars or peer-tutoring, have also been shown to have positive impacts on student experience and performance in their introductory STEM courses (Alexander, Burda, & Millar, 1997; Batz, Olsen, Dumont, Dastoor, & Smith, 2015; Murphy, Stafford, & McCreary, 1998). Future research could explore the impacts that targeted preparation and tutoring programs can have on student expectations, experiences, performance, and persistence.

Finally, faculty members who teach introductory STEM courses have the opportunity to help their students navigate the high school to first-year college instructional transition, including first-generation students who often have unique struggles. To further study the FLCs implemented for this project, the monthly meetings have been audio recorded. Audio documentation provides evidence of the ways in which faculty talk about student data and their proposed ideas of how to make instructional changes that will help to ease the high school to first-year college instructional transition for students. Additionally, a year after participating in the FLC, classroom observations of members will be completed. These observations will allow us to make comparisons about instruction before and after involvement in the FLC. For example, we will be able to examine whether there are differences in how faculty members approach the first day of class before and after participation in the program. Differences in the way faculty introduce the components of the course to students or acknowledge the high school to first-year college transition students will be investigated.

Conclusions

In order to investigate student experiences of the high school to first-year college instructional transition, this project focused on the analysis of student predictions and perceptions of the types of instructional practices used in introductory STEM courses. Results showed that student predictions about the instructional practices in introductory STEM courses differed based on certain demographic variables, including first-semester and first-generation student status. However, all students underpredicted the percent of class time they would spend listening to lecture in their college STEM courses. Furthermore, the predictions of first-generation and first-semester college students were less well aligned with actual teaching practices than those of their peers. These differences between student predictions and actual instructional practices could be contributing to students' decisions to leave STEM majors. Current research suggests that faculty may run into resistance when implementing active learning strategies, because they are violating the expectations students hold about what a 'typical' college course looks like. However, this investigation indicated that all students, and particularly first-generation and first-semester students, are predicting less lecture than their peers. Thus, we would recommend that faculty who teach introductory STEM courses decrease the percentage of class time spent lecturing and increase the percentage of class time dedicated to active learning activities. A change in instructional practices would not only more closely match student expectations and values, but also better allow for the incorporation of evidence-based teaching strategies shown to benefit student learning outcomes. Additionally, this change in instructional practices at the college level could decrease the large shift in instructional practices that students experience during the high school to first-year college instructional transition, thereby helping students more successfully navigate this transition and pursue their intended STEM majors.

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APPENDIX A: UPDATES TO SURVEY QUESTIONS

Table A.1. Content questions on Fall 2017 pilot First-Week Survey compared to content questions as adapted for Fall 2018 First-Week Survey

	Fall 2017		Fall 2018	
	Question	**Type of Question**	**Question**	**Type of Question**
A	What is the highest level [subject] course you took in high school? a. I did not take any [subject] courses in high school b. I took regular [subject] in high school. c. I took honors [subject] in high school. d. I took AP, IB, dual-enrollment, or other college-equivalent [subject] in high school.	Multiple choice	Did you take a [subject] course in high school? a. Yes, I took at least one [subject] course in high school. b. No, I did not take any [subject] courses in high school. What is the highest level [subject] course you took in high school? a. I took AP, IB, dual-enrollment, or other college equivalent [subject] in high school. b. I did NOT take AP, IB, dual enrollment, or other college equivalent [subject] in high school.	Multiple choice
B			Answer all of the following questions while thinking specifically about the portion of your [course #] course that takes place [days and times]. Please do NOT include any laboratory or recitation components of the course when answering these questions.	
C	On average, for what percent of class time do you expect the following to occur? (slide bar with values from 0-100)	Slide bar, no required total	Consider the portion of your current [course #] class that meets on [days and times]. On a typical day, for what percentage of class time do	Type in percentages must add to 100%

Table A.1 Continued

	a. Students listen to lecture b. Students work alone to answer clicker questions (questions that require students to enter their answers through a digital device such as a clicker, phone, or computer), worksheets, or other problems. c. Students work in groups to answer clicker questions, worksheets, or other problems		you expect the following to occur? Make sure your answers total 100% a. **The instructor <u>lectures</u> to the students.** *For example, the instructor presents material to the students while students are asked to listen and take notes*: ___ b. **The instructor asks students <u>to work alone</u>.** *For example, students are asked to answer clicker questions (questions that require students to share their answers through a digital device such as a clicker, phone, or computer, or through non digital means such as colored cards), complete worksheets, or solve other problems. Please* ***do not*** *include taking notes*. : _______ c. **The instructor asks students to <u>work in groups</u>**. *For example, students are asked to work in groups to answer clicker questions, complete worksheets, or solve other problems*. : _______ d. **The instructor asks students to do <u>other</u> things**. *For example, students are asked to watch a video or demonstration or to give presentations*. : _______ Total: _____	
D			What experiences or information did you use to make the predictions	Open ended

Table A.1 Continued

			about how class time will be spent (for example, experiences or information you received before or during the semester)?	
E	On average, how often do you expect the following to occur? (Never, A couple times per semester, A couple times per month, A couple times per week, A couple times per class) a. The instructor asks students a clicker question that they are expected to answer b. The instructor asks questions to the class and students raise their hands and share their answers with the class c. The instructor answers a question from a student in front of the entire class. d. The instructor provides explanations after students have completed a question or activity. e. The instructor approaches and has one on one discussions with students individually or in small groups during an activity f. The instructor shows a demonstration, experiment, simulation, video, or animation.	5-point Likert scale for each item	Consider the portion of your current [course #] class that meets on [days and times]. How often do you expect the following to occur? (Frequently/every class period, Occasionally/not every class period, Never) a. The instructor asks students a question that they are expected to answer with a clicker or other device b. The instructor asks questions to the class and students raise their hands and share their answers with the class. c. The instructor answers a question from a student with the rest of the class listening. d. The instructor provides explanations after students have completed a question or activity. e. The instructor or other instructional assistant moves throughout the class to help students when they have questions (typically during an activity). f. The instructor or other instructional assistant has one-on-one or small group discussions with students during an activity. g. The instructor shows a demonstration, experiment, simulation, video, or animation.	3 point Likert scale for each item

Table A.1 Continued

F			In the portion of your current [course #] class that meets [days and times] what mixture of lecture and active learning do you feel will be best for your learning? Please indicate the percentage of time that should be dedicated to each, and be sure your numbers add up to 100%. a. Percentage of time dedicated to lecture (e.g., the instructor presenting material, students listening and taking notes) : ___ b. Percentage of time dedicated to active learning (e.g., group activities, talking with peers, asking questions, answering clicker question or other questions) : ___ Total: _____	Type in percentage, must add to 100%
G	How do you expect the use of class time in your current [subject] course to be different from the [subject] courses you took in high school?	Open ended	How do you expect [course #] to compare with the [subject] courses you took in high school? (less than in high school [subject] courses, about the same as in high school [subject] courses, more than in high school [subject] courses) a. The total amount of in-class time I spend actively engaged (e.g., talking with peers, working on practice problems, and answering clicker-style questions) in [course 3] will be… b. The amount of attention I receive from the instructor during class time in [course #] will be… c. The amount of in-class time used to complete homework in [course #] will	3 point scale response for each item

Table A.1 Continued

			be… d. The difficulty of [course #] will be…	
H	What concerns, if any, do you have regarding these differences in how class time is used?	Open ended	Each of the following represents a concern you may have regarding [course #]. Please place each item in the box that best represents you level of concern. If there is something you are concerned about that is not listed, you may type it into one of the blank boxes. (I am very concerned about, I am somewhat concerned about, I am not concerned about) a. the class having too much lecture b. the class having too many activities (e.g., talking with peers, working on practice problems, and answering clicker style questions. c. being able to pay attention for the entire class period d. receiving too few in-depth explanations e. being able to get help f. receiving too few practice problems g. the course being too difficult h. knowing what to study i. my professor going off topic too often j. speaking in a class with a large number of students k. being expected to do too much independent learning outside of class l. having the necessary skills/background to succeed in this course m. other____ n. other_______	3 point scale response for each item

Table A.1 Continued

I			Which of the above are you most concerned about and why?	Open ended
J	If you were given the opportunity, what questions would you ask your high school teachers and college instructors about how to succeed in your college [subject] course?	Open ended	If you were given the opportunity, what questions would you ask your high school teachers and college instructors about how to succeed in your college [subject] course?	Open ended

Table A.2 Content questions on Fall 2017 pilot Mid-Semester Survey compared to content questions as adapted for Fall 2018 Mid-Semester Survey

	Fall 2017		Fall 2018	
	Question	**Type of Question**	**Question**	**Type of Question**
A	What is the highest level [subject] course you took in high school? e. I did not take any [subject] courses in high school f. I took regular [subject] in high school. g. I took honors [subject] in high school. h. I took AP, IB, dual-enrollment, or other college-equivalent [subject] in high school.	Multiple choice	Did you take a [subject] course in high school? c. Yes, I took at least one [subject] course in high school. d. No, I did not take any [subject] courses in high school. What is the highest level [subject] course you took in high school? c. I took AP, IB, dual-enrollment, or other college equivalent [subject] in high school. d. I did NOT take AP, IB, dual enrollment, or other college equivalent [subject] in high school.	Multiple choice
B			Answer all of the following questions while thinking specifically about the portion of your [course #] course that takes place [days and times]. Please do NOT include any laboratory or recitation components of the course when answering these questions.	
C	On average, for what percent of class time has the following occurred in your current [subject] course? (slide bar with values from 0-100)	Slide bar, no required total	Consider the portion of your current [course #] class that meets on [days and times]. On a typical day, for what percentage of class time does the following occur?	Type in percentages must add to 100%

Table A.2. Continued

	d. Students listen to lecture e. Students work alone to answer clicker questions (questions that require students to enter their answers through a digital device such as a clicker, phone, or computer), worksheets, or other problems. f. Students work in groups to answer clicker questions, worksheets, or other problems		Make sure your answers total 100% e. **The instructor <u>lectures</u> to the students.** *For example, the instructor presents material to the students while students are asked to listen and take notes*:___ f. **The instructor asks students <u>to work alone</u>.** *For example, students are asked to answer clicker questions (questions that require students to share their answers through a digital device such as a clicker, phone, or computer, or through non digital means such as colored cards), complete worksheets, or solve other problems. Please* ***do not*** *include taking notes*. : ______ g. **The instructor asks students to <u>work in groups</u>**. *For example, students are asked to work in groups to answer clicker questions, complete worksheets, or solve other problems*. : ______ h. **The instructor asks students to do <u>other</u> things**. *For example, students are asked to watch a video or demonstration or to give presentations*. : ______ Total: _____	

Table A.2. Continued

D	On average, how often has the following occurred in your current [subject] course? (Never, A couple times per semester, A couple times per month, A couple times per week, A couple times per class) g. The instructor asks students a clicker question that they are expected to answer h. The instructor asks questions to the class and students raise their hands and share their answers with the class i. The instructor answers a question from a student in front of the entire class. j. The instructor provides explanations after students have completed a question or activity. k. The instructor approaches and has one on one discussions with students individually or in small groups during an activity l. The instructor shows a demonstration, experiment, simulation, video, or animation.	5-point Likert scale for each item	Consider the portion of your current [course #] class that meets on [days and times]. How often do the following to occur? (Frequently/every class period, Occasionally/not every class period, Never) h. The instructor asks students a question that they are expected to answer with a clicker or other device i. The instructor asks questions to the class and students raise their hands and share their answers with the class. j. The instructor answers a question from a student with the rest of the class listening. k. The instructor provides explanations after students have completed a question or activity. l. The instructor or other instructional assistant moves throughout the class to help students when they have questions (typically during an activity). m. The instructor or other instructional assistant has one on one or small group discussions with students during an activity. n. The instructor shows a demonstration, experiment, simulation, video, or animation.	3 point Likert scale for each item
E	How useful do you feel the following in-class activities are for your learning in [course #]? (If	5-point Likert scale for each	In the portion of your current [course #] that meets on [days and times], how useful do you think	

Table A.2. Continued

	an activity did not happen in the class, please select Not Applicable). (Not useful, slightly useful, moderately useful, useful, very useful, not applicable) a. listening to course lectures b. talking to my peers c. answering questions that are posed to the entire class d. group activities answering clicker questions	item	the following in-class activities are for your learning? (very useful, useful, moderately useful, slightly useful, not useful, this does not happen in my class) a. Listening to course lectures b. The instructor asking a question to the entire class and one or more students raising their hands to answer the question out loud c. Working with a group on class activities or worksheets d. Thinking about a clicker question on my own e. Discussing clicker questions with my neighbors	
F	What mixture of lecture and active learning (e.g., group activities, talking with peers, clicker questions) do you feel is best for learning in [course #]? Please indicate the percentage of time that should be dedicated to each, and be sure your numbers add to 100%. a. Percentage of time dedicated to lecture: _____ Percentage of time dedicated to active learning: _____	Type in percentage, must add to 100%	In the portion of your current [course #] class that meets [days and times] what mixture of lecture and active learning do you feel is best for your learning? Please indicate the percentage of time that should be dedicated to each, and be sure your numbers add up to 100%. c. Percentage of time dedicated to lecture (e.g., the instructor presenting material, students listening and taking notes) : ___ d. Percentage of time dedicated to active learning (e.g., group activities, talking with peers, asking questions, answering clicker question or other questions) : ___	Type in percentage, must add to 100%

Table A.2. Continued

			Total: _____	
G	How has the use of class time in your current [subject] course been different than the [subject] course(s) you took in high school?	Open ended	How does [course #] compare with the [subject] courses you took in high school? (less than in high school [subject] courses, about the same as in high school [subject] courses, more than in high school [subject] courses) e. The total amount of in-class time I spend actively engaged (e.g., talking with peers, working on practice problems, and answering clicker-style questions) in [course 3] is… f. The amount of attention I receive from the instructor during class time in [course #] is… g. The amount of in-class time used to complete homework in [course #] is… h. The difficulty of [course #] is…	3 point scale response for each item
H	What concerns, if any, do you have regarding these differences in how class time is used?	Open ended	Each of the following represents a concern you may have regarding [course #]. Please place each item in the box that best represents you level of concern. If there is something you are concerned about that is not listed, you may type it into one of the blank boxes. (I am very concerned about, I am somewhat concerned about, I am not concerned about) o. the class having too much lecture p. the class having too many	3 point scale response for each item

Table A.2. Continued

			activities (e.g., talking with peers, working on practice problems, and answering clicker style questions. q. being able to pay attention for the entire class period r. receiving too few in-depth explanations s. being able to get help t. receiving too few practice problems u. the course being too difficult v. knowing what to study w. my professor going off topic too often x. speaking in a class with a large number of students y. being expected to do too much independent learning outside of class z. having the necessary skills/background to succeed in this course aa. other____ bb. other_______	
I			Which of the above are you most concerned about and why?	Open ended
J	If you were given the opportunity, what questions would you ask your high school teachers and college instructors about how to succeed in your college [subject] course?	Open ended	If you were given the opportunity, what questions would you ask your high school teachers and college instructors about how to succeed in your college [subject] course?	Open ended
K			What advice would you give to incoming students about how to succeed in your college [subject] course?	Open ended

APPENDIX B: FULL SURVEYS

B.1: First-Week Survey

Q1 **In order to receive credit, please provide your first name, last name, and your student ID number. This information is used to record your participation.**

- First Name ____
- Last Name ____
- Student ID Number ____

Q2 **Are you 18 years of age or older?**

- Yes
- No

Q3 **Did you take a [subject] course in high school?**

- Yes, I took at least one [subject] course in high school.
- No, I did not take any [subject] courses in high school.

Q4 **What is the highest level [subject] course you took in high school?**

- I took AP, IB, dual-enrollment, or other college equivalent [subject] in high school.
- I did NOT take AP, IB, dual-enrollment, or other college equivalent [subject] in high school.

Q5 **Answer all of the following questions while thinking specifically about the portion of your [course #] course that takes place [days and times]. Please do NOT include any laboratory or recitation components of the course when answering these questions.**

Q6 **Consider the portion of your current [course #] class that meets on [days and times]. On a typical day, for what percentage of class time do you expect the following to occur?**

Make sure your answers total 100%.

The instructor <u>lectures</u> to the students. *For example, the instructor presents material to the students while students are asked to listen and take notes.* : _______
The instructor asks students to <u>work alone</u>. *For example, students are asked to answer clicker questions (questions that require students to share their answers through a digital device such as a clicker, phone*

or computer, or through non digital means such as colored cards), complete worksheets, or solve other problems. Please ***do not*** *include taking notes.* : _______

The instructor asks students to work in groups. *For example, students are asked to work in groups to answer clicker questions, complete worksheets, or solve other problems.* : _______

The instructor asks students to do other things. *For example, students are asked to watch a video or demonstration or to give presentations.* : _______

Total : ________

Q7 **What experiences or information did you use to make the predictions about how class time will be spent (for example, experiences or information you received before or during the semester)?**

____

____

____

____

____

Q8 **Consider the portion of your current [course #] class that meets on [days and time]. How often do you expect the following to occur?**

	Frequently (every class period)	**Occasionally** (not every class period)	**Never**
The instructor asks students a question that they are expected to answer with a clicker or other device.			
The instructor asks questions to the class and students raise their hands and share their answers with the class.			
The instructor answers a question from a student with the rest of			

the class listening.			
The instructor provides explanations after students have completed a question or activity.			
The instructor or other instructional assistant moves throughout the class to help students when they have questions (typically during an activity).			
The instructor or other instructional assistant has one-on-one or small group discussions with students during an activity.			
The instructor shows a demonstration, experiment, simulation, video, or animation.			

Q9 **In the portion of your current [course #] class that meets [days and times], what mixture of lecture and active learning do you feel will be best for your learning? Please indicate the percentage of time that should be dedicated to each, and be sure your numbers add to 100%.**

Percentage of time dedicated to lecture (e.g., the instructor presenting material, students listening and taking notes) : _______
Percentage of time dedicated to active learning (e.g., group activities, talking with peers, asking questions, answering clicker or other questions) : _______

Total : ________

Q10 **How do you expect [course #] to compare with the science course(s) you took in high school?**

	less than in high school science courses.	about the same as in high school science courses.	more than in high school science courses.
The total amount of in-class time I spend actively engaged (e.g., talking with peers, working on practice problems, and answering clicker-style questions) in [course #] will be...			
The amount of attention I receive from the instructor during class time in [course #] will be...			
The amount of in-class time used to complete homework in [course #] will be...			
The amount of independent learning I am expected to do outside of class in [course #] will be...			
The difficulty of [course #] will be...			

Q11 **How do you expect [course #] to compare with the [subject] courses you took in high school?**

	less than in high school [subject] courses.	about the same as in high school [subject] courses.	more than in high school [subject] courses.

The total amount of in-class time I spend actively engaged (e.g., talking with peers, working on practice problems, and answering clicker-style questions) in [course #] will be...			
The amount of attention I receive from the instructor during class time in [course #] will be...			
The amount of in-class time used to complete homework in [course #] will be...			
The amount of independent learning I am expected to do outside of class in [course #] will be...			
The difficulty of [course #] will be...			

Q12 **Each of the following represents a concern you may have regarding [course #]. Please place each item in the box that best represents your level of concern. If there is something you are concerned about that is not listed, you may type it into one of the blank boxes.**

	I am very concerned about...	I am somewhat concerned about...	I am not concerned about...
______ the class having too much lecture.			

_______ the class having too many activities (e.g., talking with peers, working on practice problems, and answering clicker-style questions).			
_______ being able to pay attention for the entire class period.			
_______ receiving too few in-depth explanations.			
_______ being able to get help.			
_______ receiving too few practice problems.			
_______ the course being too difficult.			
_______ the pace of the course being too fast.			
_______ knowing what to study.			
_______ my professor going off-topic too often.			
_______ speaking in a class with a large number of students.			
_______ being expected to do too much independent learning			

outside of class.			
______ having the necessary skills/background to succeed in this course.			
______ Other			
______ Other			

Q13 **Which of the items above are you most concerned about and why?**

____

____

____

____

____

Q14 **If you were given the opportunity, what questions would you ask your high school teachers and college instructors about how to succeed in your college [subject] course?**

____

____

____

____

____

Q15 **Note: You may choose to leave any or all of the following questions blank. Your answers will be used to better understand characteristics of students taking this survey.**

Q16 **What is your current class standing?**

- First-year
- Sophomore
- Junior
- Senior
- Postbaccalaureate
- Graduate student
- Not listed above ____
- Prefer not to answer

Q17 **Is this your first-semester taking courses on a college campus?**

- Yes
- No
- Prefer not to answer

Q18 **Are you a transfer student?**

- Yes
- No
- Prefer not to answer

Q19 **Have you participated in one or more of the following pre-college programs designed to bridge the gap between high school to college: [program titles] ?**

- Yes
- No
- Other ____
- Prefer not to answer

Q20 **Gender**

- Male
- Female
- Not listed above ____
- Prefer not to answer

Q21 **Race/Ethnicity (select all that apply)**

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian
- White
- Not listed above ____
- Prefer not to answer

Q22 **Did you speak English at home when you were growing up?**

- Yes
- No
- Prefer not to answer

Q23 **Are you an international student?**

- Yes
- No
- Prefer not to answer

Q24 **Highest level of education completed by at least one of your parents:**

- Did not complete high school
- High school/GED
- Some college (but did not complete college)
- Associate's degree (2-year degree)
- Bachelor's degree
- Master's degree
- Advanced graduate degree (e.g., DVM, MD, PhD)
- Unknown
- Prefer not to answer

Q25 **How likely are you to graduate with a Science, Technology, Engineering, or Mathematics (STEM) major?**

- Very likely
- Likely
- Unsure
- Unlikely
- Very unlikely
- Prefer not to answer

Q26 **I graduated from a high school:**

- in the state of Maine
- outside the state of Maine
- Prefer not to answer

B.2: Mid-Semester Survey

Q1 **In order to receive credit, please provide your first name, last name, and your student ID number. This information is used to record your participation.**

- First Name ____
- Last Name____
- Student ID____

Q2 **Are you 18 years of age or older?**

- Yes
- No

Q3 **Did you take a [subject] course in high school?**

- Yes, I took at least one [subject] course in high school.
- No, I did not take any [subject] courses in high school.

Q4 **What is the highest level [subject] course you took in high school?**

- I took AP, IB, dual-enrollment, or other college equivalent [subject] in high school.
- I did NOT take AP, IB, dual-enrollment, or other college equivalent [subject] in high school.

Q5 **Answer all of the following questions while thinking specifically about the portion of your [course #] course that takes place [days and times]. Please do NOT include any laboratory or recitation components of the course when answering these questions.**

Q6 **Consider the portion of your current [course #] class that meets on [days and times]. On a typical day, for what percentage of class time does the following occur?**

Make sure your answers total 100%.

The instructor <u>lectures</u> to the students. *For example, the instructor presents material to the students while students are asked to listen and take notes.* : _______
The instructor asks students to <u>work alone</u>. *For example, students are asked to answer clicker questions (questions that require students to share their answers through a digital device such as a clicker, phone or computer, or through non digital means such as colored cards), complete worksheets, or solve other problems. Please* ***do not*** *include taking notes.* : _______
The instructor asks students to <u>work in groups.</u> *For example, students are asked to work in groups to answer clicker questions, complete worksheets, or solve other problems.* : _______
The instructor asks students to do <u>other</u> things. *For example, students are asked to watch a video or demonstration or to give presentations.* : _______

Total : ________

Q7 **Consider the portion of your <u>current [course #] class</u> that meets on [days and time]. How often do the following occur?**

	Frequently (every class period)	**Occasionally** (not every class period)	**Never**
The instructor asks students a question that they are expected to answer with a clicker			

or other device.			
The instructor asks questions to the class and students raise their hands and share their answers with the class.			
The instructor answers a question from a student with the rest of the class listening.			
The instructor provides explanations after students have completed a question or activity.			
The instructor or other instructional assistant moves throughout the class to help students when they have questions (typically during an activity).			
The instructor or other instructional assistant has one-on-one or small group discussions with students during an activity.			
The instructor shows a demonstration, experiment, simulation, video, or animation.			

Q8 **In the portion of your <u>current [course #] class</u> that meets on [days and time], how useful do you think the following in-class activities are for your learning?**

	Very Useful	Useful	Moderately Useful	Slightly Useful	Not Useful	This does not happen in my class
Listening to course lectures						
The instructor asking a question to the entire class and one or more students raising their hands to answer the question out loud						
Working with a group on class activities or worksheets						
Thinking about a clicker question on my own						
Discussing clicker questions with my neighbors						

Q9 **In the portion of your current [course #] class that meets [days and times], what mixture of lecture and active learning do you feel is best for your learning? Please indicate the percentage of time that should be dedicated to each, and be sure your numbers add to 100%.**

Percentage of time dedicated to lecture (e.g., the instructor presenting material, students listening and taking notes) : _______
Percentage of time dedicated to active learning (e.g., group activities, talking with peers, asking questions, answering clicker or other questions) : _______

Total : ________

Q10 **How does [course #] compare with the science course(s) you took in high school?**

	less than in high school science courses.	about the same as in high school science courses.	more than in high school science courses.
The total amount of in-class time I spend actively engaged (e.g., talking with peers, working on practice problems, and answering clicker-style questions) in [course #] is...			
The amount of attention I receive from the instructor during class time in [course #] is...			
The amount of in-class time used to complete homework in [course #] is...			
The amount of independent learning I am expected to do outside of class in [course #] is...			

The difficulty of [course #] is...			

Q11 **How does [course #] compare with the [subject] courses you took in high school?**

	less than in high school [subject] courses.	about the same as in high school [subject] courses.	more than in high school [subject] courses.
The total amount of in-class time I spend actively engaged (e.g., talking with peers, working on practice problems, and answering clicker-style questions) in [course #] is...			
The amount of attention I receive from the instructor during class time in [course #] is...			
The amount of in-class time used to complete homework in [course #] is...			
The amount of independent learning I am expected to do outside of class in [course #] is...			
The difficulty of [course #] is...			

Q12 **Each of the following represents a concern you may have regarding [course #]. Please place each item in the box that best represents your level of concern. If there is something you are concerned about that is not listed, you may type it into one of the blank boxes.**

	I am very concerned about...	I am somewhat concerned about...	I am not concerned about...
_______ the class having too much lecture.			
_______ the class having too many activities (e.g., talking with peers, working on practice problems, and answering clicker-style questions).			
_______ being able to pay attention for the entire class period.			
_______ receiving too few in-depth explanations.			
_______ being able to get help.			
_______ receiving too few practice problems.			
_______ the course being too difficult.			
_______ the pace			

of the course being too fast.			
_______ knowing what to study.			
_______ my professor going off-topic too often.			
_______ speaking in a class with a large number of students.			
_______ being expected to do too much independent learning outside of class.			
_______ having the necessary skills/background to succeed in this course.			
_______ Other			
_______ Other			

Q13 **Which of the items above are you most concerned about and why?**

____

____

____

____

____

Q14 **If you were given the opportunity, what questions would you ask your high school teachers and college instructors about how to succeed in your college [subject] course?**

____

____

____

____

____

Q15 **What advice would you give to incoming students about how to succeed in your college [subject] course?**

____

____

____

____

____

Q16 **Note: You may choose to leave any or all of the following questions blank. Your answers will be used to better understand characteristics of students taking this survey.**

Q17 **What is your current class standing?**

- First-year
- Sophomore
- Junior
- Senior
- Postbaccalaureate
- Graduate student
- Not listed above ____
- Prefer not to answer

Q18 **Is this your first-semester taking courses on a college campus?**

- Yes
- No
- Prefer not to answer

Q19 **Are you a transfer student?**

- Yes
- No
- Prefer not to answer

Q20 **Have you participated in one or more of the following pre-college programs designed to bridge the gap between high school to college: [program titles] ?**

- Yes
- No
- Other ____
- Prefer not to answer

Q21 **Gender**

- Male
- Female
- Not listed above ____
- Prefer not to answer

Q22 **Race/Ethnicity (select all that apply)**

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian
- White
- Not listed above ____
- Prefer not to answer

Q23 **Did you speak English at home when you were growing up?**

- Yes
- No
- Prefer not to answer

Q24 **Are you an international student?**

- Yes
- No
- Prefer not to answer

Q25 **Highest level of education completed by at least one of your parents:**

- Did not complete high school
- High school/GED
- Some college (but did not complete college)
- Associate's degree (2-year degree)
- Bachelor's degree
- Master's degree
- Advanced graduate degree (e.g., DVM, MD, PhD)
- Unknown
- Prefer not to answer

Q26 **How likely are you to graduate with a Science, Technology, Engineering, or Mathematics (STEM) major?**

- Very likely
- Likely
- Unsure
- Unlikely
- Very unlikely
- Prefer not to answer

Q27 **I graduated from a high school:**

- in the state of Maine
- outside the state of Maine
- Prefer not to answer

BIOGRAPHY OF THE AUTHOR

Emma Susanne Toth was born in Methuen, Massachusetts on May 22, 1995. She grew up in Sandown, NH, and graduated from Timberlane Regional High School in 2013. She attended the University of Maine and graduated summa cum laude in 2017 with a Bachelor's degree in Biology, a minor in Neuroscience, and a Pre-Medical Concentration. Emma is a candidate for the Master of Science in Teaching degree from the University of Maine in May 2019.